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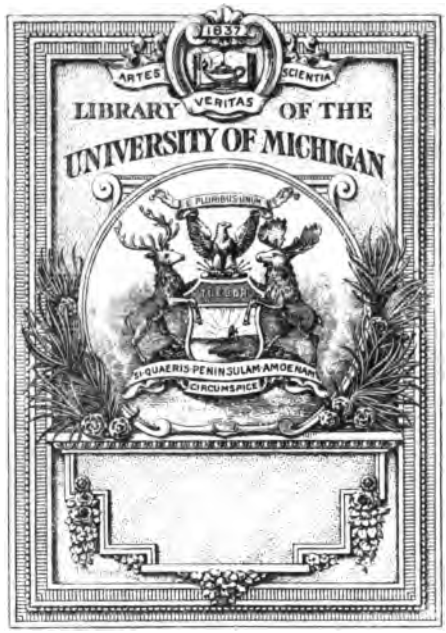
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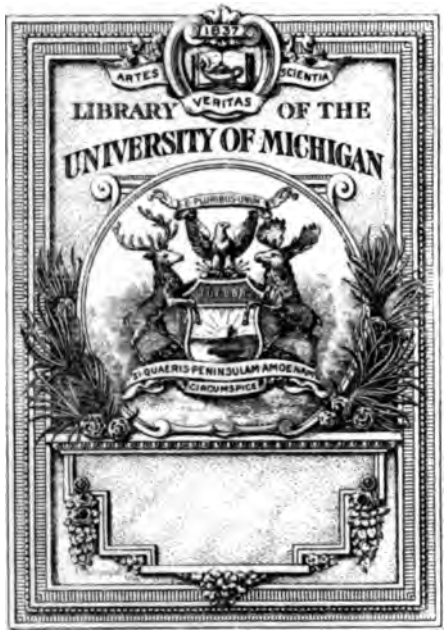
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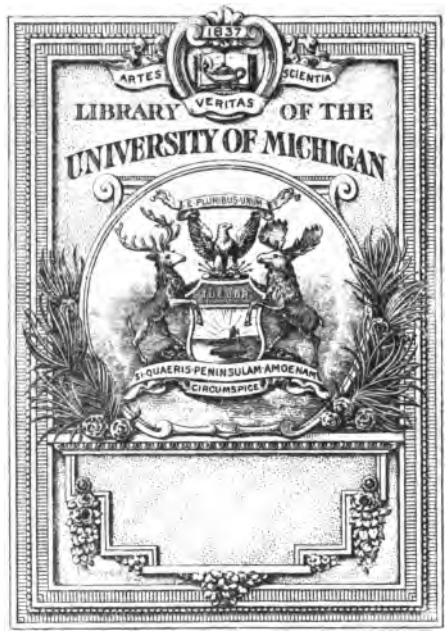
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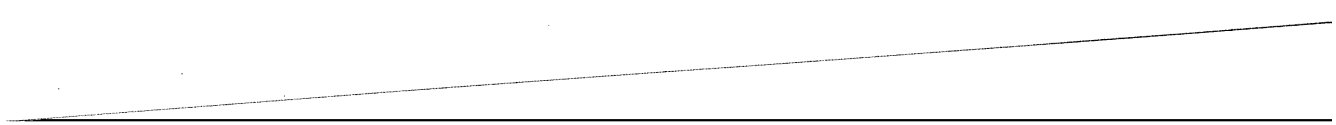
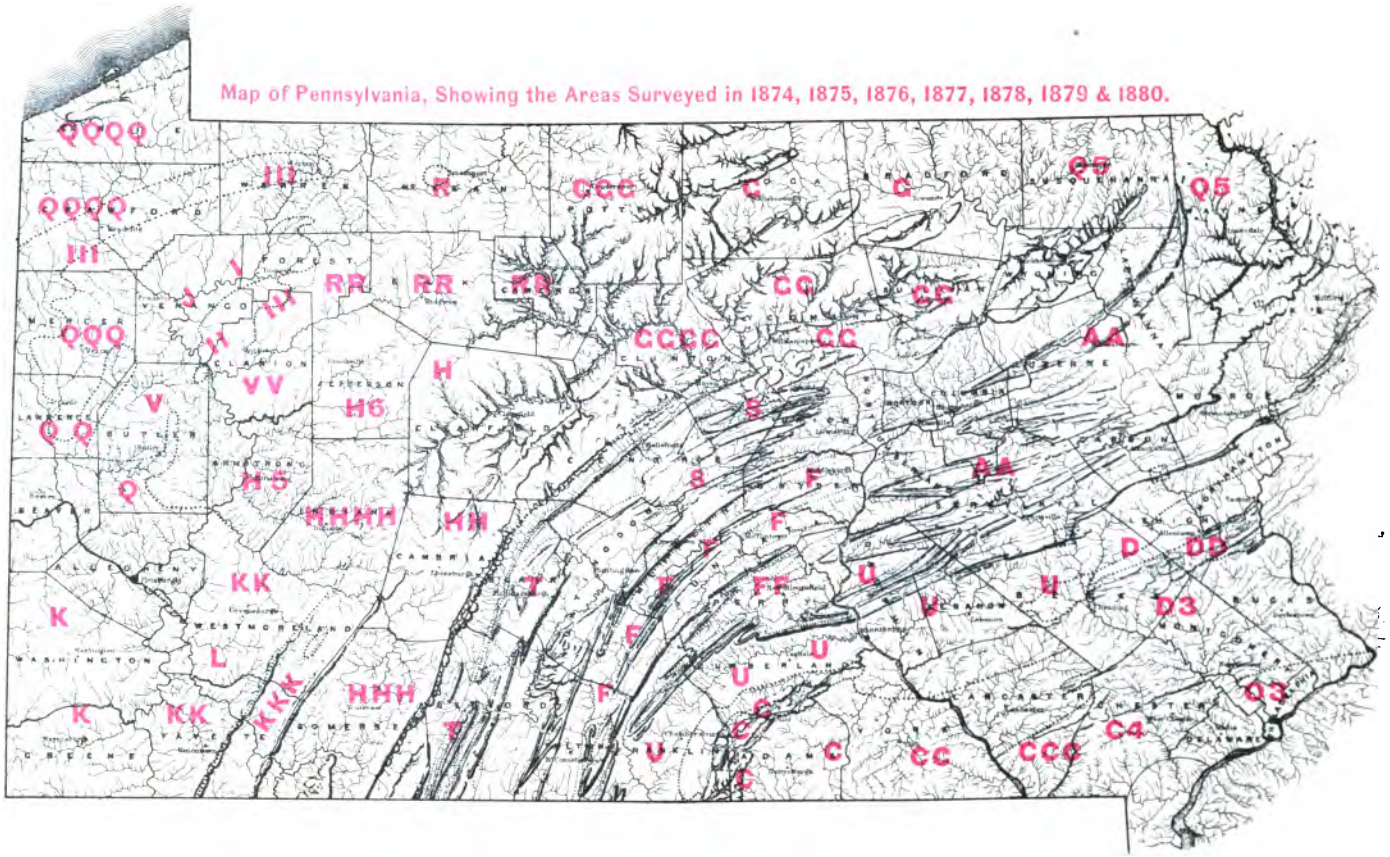


Map of Pennsylvania, Showing the Areas Surveyed in 1874, 1875, 1876, 1877, 1878, 1879 & 1880.



SECOND GEOLOGICAL SURVEY OF PENNSYLVANIA:

REPORT OF PROGRESS, 1879.

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THE GEOLOGY OF

ERIE AND CRAWFORD COUNTIES

BY

I. C. WHITE.

WITH TWO COLORED GEOLOGICAL COUNTY MAPS; 107 VERTICAL SECTIONS; TABLES OF BAROMETRIC HEIGHTS IN EACH TOWNSHIP; AN INDEX OF NAMES OF PERSONS AND PLACES; AND NOTES ON THE PLACE OF THE SHARON CONGLOMERATE IN THE PALÆOZOIC SERIES.

DISCOVERY

OF THE

PREGLACIAL OUTLET OF LAKE ERIE.

BY

J. W. SPENCER, PH. D.

WITH TWO MAPS OF THE LAKE REGION.

HARRISBURG:

PUBLISHED BY THE BOARD OF COMMISSIONERS

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1881.

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PHILADELPHIA, *February 12, 1881.*

To His Excellency HENRY M. HOYT, *Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania:*

SIR: In presenting Professor I. C. White's report on Erie and Crawford counties I beg leave to call your attention to the evident care bestowed upon the geological structure of the district, the skillful discrimination of the formations which belt it and the valuable lists of barometric observations recorded for every township.

Unlike the counties lying further south of which his previous reports treat, these two counties of Crawford and Erie are almost destitute of coal, iron ore and petroleum.

On the other hand stone quarries are numerous and valuable; and the gas wells of the Lake Erie shore have been and are still sources of wealth.

The small areas of coal which remain along the southern border of Crawford are locally important. Most of them have been discovered in past years by boring through the universal covering of glacial gravel; and it is probable that there still remain spots which would repay research. A valuable feature of this report is the location and definition of these areas, with so clear and full a statement of the facts as to prevent further waste of money in a search for coal in other parts of the district.

The same may be said of the few and scattered exhibitions of iron ore.

In respect of petroleum the case is different. It is difficult to express in a few words, or to make clear to unprofessional readers the great value of Mr. White's results. They will certainly influence future explorations.

So many wells have been sunk in Crawford and Erie counties from none of which large quantities of oil have been obtained, that the whole region is looked upon as

lying outside of the oil regions; the oil sands of Venango, Butler, Clarion and Warren being supposed to exist only in the southeastern part of Clearfield, and to fine out and disappear in Erie county.

Mr. White's survey seems to show that this is not strictly speaking the fact. The sands are certainly not coarse, thick, persistent, largely oil producing deposits as in the "oil belts" further east and south. But they exist nevertheless as deposits, in regular place and order among the rocks, and spread beneath the whole of Crawford and half of Erie county. The upper sands are unimportant; but the lowest or *Third sand* not only crops out in a line across the region, but is everywhere charged with a sufficient quantity of petroleum to produce oil springs and pools of asphalt upon the surface of the ground.

The time is sure to come when that vast production of petroleum to which the markets of the world have grown accustomed, on which large refining establishments are founded, on which railroad companies, pipe line companies and ship owners build up fortunes, on which, in a word, Pennsylvania prides herself as the source of light fuel to the civilized world—will dwindle to moderate dimensions and take its place among the marvels of a past history. Nothing in the shape of a natural history or geological fact can be more clearly demonstrated than this statement. Although the date of the decline cannot be predicted and may be postponed for ten or twenty or thirty years, the day is sure to come when our oil fields will be exhausted of their enormous ancient accumulations, and there will only remain what may be called the leavings and drainings.

The fatal day may be put still further off by the discovery of oil producing belts underlying Forest, Elk, Cameron, Clearfield, Jefferson and Indiana counties. But as yet we have no very reliable reasons for expecting this; and some good reasons for not expecting it; at least so far as the Venango sands are concerned. The Bradford shales may be productive anywhere, for all we know, but at a great depth; and great depth seems hostile to petroleum.

There will come a time then, when the old oil fields will

be re-occupied and "dry country" receive attention—attention impossible so long as the great flow lasts. The production of oil will then become a systematic and quiet industry, spread over wide areas, and regulated on a different system from that in vogue. When that time comes Crawford and Erie counties will be re-tested; and small quantities of petroleum will probable be obtained at various places from the Venango sands which are now considered worthless.

The value of this report will then be recognized, as offering data for determining the areas and depths of the oil sands throughout the district. The mistake of drilling at and beneath the outcrop of the Third Sand to strike the Venango sands (as described on page 113) can not again be made by intelligent readers of this report.

The cost of the survey has been justified merely by one result (setting aside the rest), namely, the determination by sufficient evidence that the *Third Oil Sand* of Venango county is the *Quarry-rock* of Erie county, (see page 106,) and that this deposit in crossing Erie county changes its character from a muddy sandstone in the western townships, to a coarse gravel rock east of LeBoeuf creek, becoming the *Panama Conglomerate* in the State of New York; everywhere charged with a peculiar group of fossil shells and seaweed; and with petroleum which has evidently resulted from their decomposition. (See this subject discussed on pages 112 to 116.)

The doubt which Mr. Carll has expressed in his Report III, page 69, respecting the identity of the rock at the various quarries is dispelled by Mr. White's survey. The numerous levels taken along the line of outcrop harmonize on the supposition that the rock is identical at the principal exposures; a conclusion supported by the fossils, by the oil springs, by measurements upward and downward to other established rock horizons, and by the topography. *Prima facia* it is as probable that the Panama Conglomerate should underlie Western Pennsylvania, as that the Sharon Conglomerate (750′ higher in series) should do so.

The first objection of Mr. Carll to the identification of the

Panama Conglomerate with the *Third Oil Sand*, viz: That the dip as observed in Warren county is sufficiently rapid southward to place the former under the latter, seems to be satisfactorily overcome by the discussion of the dips in Crawford and Erie counties in Chapter 5, page 45 to 54. The probable existence of a synclinal along the valley of the South branch of French creek, there indicated, would solve the difficulty in Warren county.

The second fact insisted on by Mr. Carll, viz: that the Panama Conglomerate cannot be recognized in the north Warren wells, and therefore cannot be traced southward through Warren into Venango county, loses its force in view of the thining down of the Panama Conglomerate into fine-grained sandstone westward through Erie. A similar change southward through Warren would be quite sufficient to mask its identity with the Third sand in Venango.

The mention of the *Salamanca Conglomerate* in connexion with and as if identical with the *Panama Conglomerate* in the text of this report must not be accepted as an actual observation. On the contrary, Mr. White's survey stopped at Panama, and he asserts nothing as of his own knowledge respecting the conglomerate at Salamanca, forty miles further east.

Mr. Carll has more recently pursued this special research far enough to make it nearly certain that the *Salamanca Conglomerate* overlies (geologically) the *Panama Conglomerate* by at least 300 feet,—thus representing, to all appearance, the *First Oil sand* of Venango county.*

The new oil developments in McKean, Forest and Southeast Warren counties are affording valuable assistance in tracing the Venango group and the red beds; and we may hope that it will not be long before a harmony of views will be reached.

At two points I have ventured to modify the expression of Mr. White's views in this report:

1. Respecting the classical name and age of the Erie quarry rock:—For the name *Third Oil Sand* in Mr. White's manuscript, I have substituted *Venango Lower sandstone;*

* Also the *Tuna Conglomerate* of the McKean Report?

and for the *First and Second Oil sands—Venango Upp and Middle sandstones.* This is done to mark the unit of the Venango group, and to preserve a geographical nomenclature.

I have also made one or two other slight changes in th names of rocks or groups higher up in the series; *Oil lak group* for *Oil Creek lake group*, &c.

With regard to the Chemung age of the *Venango group* or at least of its *Lower sandstone*, Mr. White is very positive, on the ground of the fossil forms. I do not accoun this a matter of serious importance; but if it were, I should not be willing to accept the fossils as absolutely conclusive evidence. For, I am quite convinced that the classification of sediments cannot be founded exclusively on the animal and vegetable forms which they preserve:—1. because our observation of these forms is very limited; 2. because the continuance of a life form does not wholly depend upon the cause which produces the sediment; may die out before the deposit of a formation is finished; or may survive into later times and appear in an overlying formation.

The main fact, demonstrated by Mr. Carll through an accumulation of evidence, is the fact that the *Venango group* of three or more oil-sands is a unit—one single formation, separate and distinct from the formations below and above it. To speak of it as deposited in more than one geological age—in two successive ages—would confuse our geological ideas, and diminish their practical usefulness. If the lower part of the Venango group be of Chemung age, then the upper part is also. If Chemung fossils in the *Third Oil Sand* make it a Chemung deposit, then the Second and the First Oil Sands are also Chemung deposits, and we must look for the fish-bearing *Catskill formation* (if present in the district) *above the First Oil Sand.* And this may be the explanation of the reds in the Dennis well, and in wells further west. (See the Fish beds of Report R.)

This view (of the Chemung age of the whole Venango group) is certainly reënforced by Mr. White's observation of Chemung fossils abundant in the overlying *Riceville shales*, Chap. 11, p. 97.

The argument for the *Catskill* age of the Venango group may be thus summarized:—

The sheet of comparative oil-well sections (see forthcoming Report R², on Forest, Elk, and Cameron Counties) selected on a parallel of latitude from Oil creek, eastward, through Forest county to the Cameron oil well, seems to make the *red beds which lie inside of the Venango oil group* the equivalents of the *red beds of the Ridgeway and Cameron wells*. The sheet of north and south well sections (see Report R, McKean county) carries this identification from Ridgeway to the Dennis well. Judging by these data it seems impossible to consider the Venango oil sand groups as *underlying* the Dennis-well red-beds; but as being identical with them. If now the red beds of McKean, Elk, and Cameron be Catskill, then the Venango group would be Catskill, and that in spite of its Chemung fossils. This is Mr. Ashburner's line of argument, and it is supported by a large number of well and surface sections in the four counties lying east of Warren and Venango counties, in which the Venango oil sand group has been so thoroughly studied by Mr. Carll.

The fact that *Azoic pebbles* are numerous in the *Venango Lower Sandstone* of Erie county is a very important fact, if this sandstone be the Third Oil Sand of Venango county; for these pebbles are a notable indication of some great change of land and sea relationship—of direction and force of currents—at that special point of time. The only supposible source of such gravel is the Blue Ridge; or the mountains of New England and Northern New York; or the mountains of Canada. So signal a change of sediments ought to indicate the end of one geological age and the beginning of another. In this case it would mark the end of an age of *Chemung olive shales*, and the beginning of an age of *Venango oil sands*.

But we have no name for any age intervening between Chemung and Catskill. Although the new age ought to be Catskill, yet if sound reasons can be presented why the Venango sands should not be called Catskill (and their Chemung fossils seem to afford such a reason) then there

is an imperative necessity for a new name, to be interposed between Chemung and Catskill, and the fossils must be provisionally called *Venango fossils of Chemung type.*

The *Chemung conglomerate* of the Potter, Tioga and Bradford reports (G, G^3) may turn out to be the *Panama conglomerate* (Venango Third sand); and Mr. White will give his reasons for thus identifying it in his forthcoming report on Susquehanna and Wayne counties (Q^5). The *Mansfield red beds* of Tioga county may prove to be the reds of the oil wells. The *Venango group* would then represent the upper part of the so-called Chemung formation of the eastern counties. It will then be a question whether this upper part must not be separated systematically from the *Chemung*, and have assigned to it a special name, *Venango.*

On the other hand, Mr. Ashburner finds a *lower set of red beds* in the Dennis and other wells of his district (McKean, Elk, Cameron) in which he is disposed to see the Mansfield red beds of Tioga and Bradford.

Thus the matter stands at present. Geologists who insist on fossil forms will call the Venango group *Upper Chemung*, and will explain the McKean sections by a total disappearance of the oil sands in an increased mass of red beds. Geologists who insist upon lithological data will call the Venango group Catskill, or even Pocono, in spite of Chemung fossils.

2. On the subject of *Glacial erosion* I have modified this report by removing from it the expression of what I consider ultra views of the power of moving ice to excavate valleys; but all observed facts are given each in its proper place. These facts are certainly of great interest; such as the crushing up of small patches of coal, and even of quarry rock, on high summits by the Canadian ice; and their subsequent concealment under many feet of moraine matter, even at a height of more than 1700 feet above the present level of the sea. The different directions taken by the moving glacier are also noted. Especially interesting are the descriptions of ancient valleys buried under several hundred feet of glacial drift deposits.

To Mr. Carll the credit is justly due of first seeing the importance of this subject in northwestern Pennsylvania, and of working out the remarkable explanation of it published in his Report III, 1881; by which the present drainage of French creek and the Allegheny river is seen to be of recent date, the previous drainage having been northward into the rock basin of Lake Erie.

According to this view the present valley system dates far back, and was very slightly modified by the attrition of the ice; but, on the other hand, and in a topographical sense, was vastly changed by the dumping of moraine matter into every channel way; the new rock-gates opening southward to let out the dammed up waters being cut by water and not by ice.

Mr. White however, being disposed to assign greater power of erosion to ice than I can admit, is disposed to consider most of the thorough-cut valleys of his district as the work of the moving glacier, and he is therefore inclined to doubt the former flow of Oil creek into French creek and of French creek by way of Conneaut creek into Lake Erie.

A remarkable discovery has recently been made by Dr. Spencer, Professor of Geology in King's College, Winsor, Nova Scotia, which seems to remove the only objection to be urged against Mr. Carll's results; or rather to add the last link in the chain of evidence in favor of preglacial drainage northward. (See Appendix.)

The only real difficulty lay in getting the drainage waters *out of* Lake Erie after they had been poured *into* it from the Pennsylvania highlands; for, the hypothesis demanded that the Lake Basin should be an open valley, through which flowed a great river; and it seemed impossible to have this river flow either eastward towards Buffalo or westward towards Toledo.

Dr. Spencer's researches offer an easy solution of the difficulty. They show that a submerged valley-bed crosses Lake Erie transversely, through which the combined streams of the Pennsylvania highland must have flowed northward towards and into a buried valley beneath the present Drift-filled water-bed of Grand river in Upper Canada; making

a right angle bend further to the north, and then passi eastward into the head of Lake Ontario near Toronto. was not until this river channel had become filled wit glacial drift that the Basin of Lake Erie became filled wit water, and Niagara falls came into existence.

The whole history of these changes is not yet made clear It has episodes not yet explained; and Mr. White's de scriptions of high shingle beaches on the slope of the di vide facing the lake will be very stimulating to a fresh study of the subject.

The Railroad levels given in Chap. 2, of this report are taken from Report N, published in 1878. They need some correction, but are approximately correct. The Phil. & Erie RR. line was re-leveled in July, 1879, by Mr. Welch of Lockhaven, and the new table published on page 11 of Report R. Extracts from it are given in the Appendix to this volume.

In the first paragraph on page 58 the expression "180 feet above the Meadville Upper Limestone" relates to the Pine Knoll coal, and not to the "Quakertown coal of Mercer county."

Mr. White prefers to include the two Sandstones named "Sharon," on page 70, with the Shenango, in one group.

Mr. White explains, that the identity of the Waverly quarry-rock of Ohio with the Berea Grit, spoken of on page 68, is only probable in his opinion and has not been completely demonstrated.

For *Productus Boydii* on page 97 and elsewhere read *Productella Boydii.* (See Index.)

Mr. White desires to correct 375′ to 390′ on page 102.

J. P. LESLEY.

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PART I.

THE

TOPOGRAPHY AND GENERAL GEOLOGY

OF

CRAWFORD AND ERIE COUNTIES.

CHAPTER I.

Area; Population; Towns.

ERIE COUNTY occupies the northwest corner of Pennsylvania, bordering on the shore of Lake Erie for 44 miles between the New York and Ohio State lines.

Its eastern border line runs due south from the Lake Erie shore, 20 miles; thence due east along the south line of New York, 8 miles; thence due south along the west line of Warren county, 11 miles.

Its southern line, the north line of Crawford county, runs due west 46 miles to the Ohio State line.

Its west line runs thence north, along the Ohio State line, 10 miles to Lake Erie.

The area of Erie county is stated to measure 480,000* acres or 740 square miles;† subdivided into 21 townships, arranged in very nearly the following order:—

			North East.	
	Mill creek.	Harbour creek.	Greenfield.	
Fairview.	Summit.	Greene.	Venango.	
Girard.	McKean.			
Springfield.	Franklin.	Waterford.	Amity.	Wayne.
Conneaut.	Elk creek.	Washington. Le Bœuf.	Union.	Concord.

The population of Erie county is given by the census reports of the United States thus:

* Gray & Walling's Atlas. † Johnson's Encyc., 1876.

In 1860,	49,432
In 1870,	65,973
In 1880,	74,681

The principal places in Erie county are:

1. *Erie*, a city of 19,646 inhabitants in 1870, and in 1880, is situated on the shore of Lake Erie, facing the harbor of Presque Isle Bay; this harbor being formed by a semi-circular peninsula, 8 miles long in arc, and 5½ in chord; attached to the main land at its western end; open near the mainland at its eastern end; composed of drift sand and gravel, and enclosing a shallow bay, 5 miles long by 2 miles wide, entirely protected from storms. It was one of the earliest trading stations and forts of the French, and figures largely in the history of the Pontiac war.

The Lake Shore and Michigan Southern railroad runs through Erie, and the Philadelphia and Erie railroad and the Erie and Pittsburgh railroad have their termini here.

The city is alive with business, and carries on an extensive steamboat and sailing traffic with Buffalo, Cleveland, Toledo, Detroit, Chicago, Milwaukee, Marquette and many other places on the shores of the great lakes; exporting petroleum, coal, iron, and machinery; and importing iron ore, lumber, and grain. Nearly a hundred factories of all kinds, iron works, oil refineries, tanneries, mills, &c., are enumerated in the description of the place.*—Level of Lake Erie above tide,† 573′; top of bluff, corner of Chestnut and Second streets, 643′; Chestnut and Seventh streets, 743′; Water in City Reservoir, 808′; L. S. & M. RR. station rail, 686′. Track at P. & E. RR. Depot, 586′.

2. *Corry* is in the south-eastern corner of Erie county, on the township line between Wayne and Concord, 37 miles south-east of Erie, by the P. & E. RR., which runs through it; 42 miles south of Brocton on the Lake Shore and Michigan Southern railroad, by the Buffalo, Corry and Pittsburgh railroad; 61 miles south-west of Salamanca on the New York and Erie railroad, by the Atlantic and Great Western railroad; and 27 miles north of Titusville by the Pittsburgh, Titusville and Buffalo railroad; which different roads have a "Union depot" in the town.

*F. A. Crandell in Johnson's Enc. †See various tables in Report N.

Corry was created in 1860 by the first "oil developments," and was the first important site of the oil refinery. A population of 6,809 is given to it in Johnson's Encyclopedia (1876), and of by the census of 1880. Its factories connected with the petroleum industry are large and numerous.—Level above tide, RR. Depot track, 1431.′

3. *Waterford*, in Waterford township, on Lake Le Boeuf, occupies the site of the old French trading station and fort of Le Boeuf, is 19 miles south of Erie by the P. & E. railroad, and 18 miles west of Corry.—Level of track at depot, 1193′.

4. Facing the lake are the following villages beginning at the west, with their distances from Erie, and their levels above tide on the L. S. & Mich. RR:

West Springfield, 2 miles south of the railroad (24 m.)

North Springfield, on the railroad, (20 m. 663′.)

Girard station on the RR. Junction with the Erie & Pittsburg railroad, (15 m. 717′.)

Girard, up the east bank of Elk creek 2 miles south of the railroad, (16 m.)

Fairview, up the east bank of Trout run, 1½ miles south of the railroad (12 m.) (RR. station, 735′.)

Swanville, overlooking the bend of Walnut creek, 1 mile south of the railroad (8 m.) (RR. Station, 735′.)

Wesleyville station, 4 miles east of Erie, (697′.)

Harbor Creek, near the railroad, east bank of Elliot's run, (8 m. 730′.)

North East, on the railroad, east of 12 mile run, (15 m. 804′.)

5. Higher up the slope, facing the lake, are the following villages, beginning at the west, with their *air line* distances from Erie:—

Albion, east of Conneaut creek; its Erie & Pittsburg RR. station west of the creek, is 26 miles by rail from Erie; (23 m. 857′ above tide.)

Cranesville and *Wellsburg*, close together on the east bank of a branch of Conneaut creek, at the west side of Elk Creek township, (20 m.)

Lockport, on the heights, south line of Girard township, (18 m.)

Stone Quarry on Fall's run, 1 mile south of Elk creek, in north west corner of Franklin township (15 m.)

Middleboro', on the north bank of Elk creek, center of McKean township (10 m. west of south from Erie.)

Bell Valley (*Belle Vallée*) on Mill creek, (3½ m. south-east of Erie, in air line, but 7 by P. & E. railway; station level 1007′.)

6. On the great divide, or south sloping table land, are the following places, with their *air line* distance from Erie:

Edinboro', at the issue of Conneautee creek from Conneautee lake, in Washington township, 18 miles S. by W. from Erie, & within 1½ miles of the Crawford county line.

Mill Village, in the center of Le Bœuf township, 1½ miles east of French Creek, and 19 miles S. S. E. air line from Erie. (Its At. & G. W. RR. station, 18 miles west of Corry, 1216′.)

Union City, on the north bank of the South Branch French Creek, opposite the P. & E. RR. station, 11 miles west of Corry, (1270′) and the At. & G. W. RR. station (1301′) (from Erie 19 m. air line and 26 m. by rail.)

Concord, station on P. & E. RR., north side of South Branch French Creek, 5 m. from Corry, and 32 from Erie (1384′.) (A. & G. W. RR. 1361′.)

Lovell's, on the A. & G. W. RR. south bank of same, 4 miles from Corry.

Beaver Dam in the Southwest corner of Wayne township.

Wattsburg in the forks of Spafford's run and North Branch French Creek, on south line of Venango township, 2 miles from the S. W. corner of New York state, (16 m. S. E. from Erie.)

Greenfield, on the North Branch French creek, (13 m. east of Erie, and 2½ from the New York state line.)

These places can be found on the colored geological map of Erie and Crawford counties accompanying this report.

CRAWFORD COUNTY lies next south of Erie, bordering on the Ohio State line, due north and south, for a distance of 24 miles.

Its north boundary line, along Erie county, runs due east 46 miles.

Its south boundary line, along Mercer county, runs due east (with one slight jog) 25½ miles, across and a little beyond (east of) French creek.—Thence, northeastward, along Venango county, by a series of nine jogs, mostly right-angled, 11½ miles measured in an air line.—Thence due east along Venango county, 11 miles, past Titusville, to the Warren county line.

Its east boundary line, along Warren county, runs due north 15 miles, to the southeast corner of Erie county.

The area of Crawford county is stated to be 629,760 acres* or 975 square miles;† subdivided into 34 townships, arranged thus:

Beaver.	Spring.	Cussewago.	Venango.	Cambridge.	Rockdale.	Bloomfield.	Sparta.
						Athens.	
Conneaut.	Summerhill.	Hayfield.	Woodcock,		Richmond.		Rome.
Pine.						Steuben.	
N. Shenango.	Summit.	Vernon.	Mead.		Randolph.		Oil Creek.
S. Shenango.	Sadsbury.	Union.	E. Fairfield.			Troy.	
					Wayne.		
W. Shen.	W.F.	E. Fallowfield.	Greenwood.	Fairfield.			

The population of Crawford county is given by the census reports, as follows:

In 1860,	48,755
In 1870,	63,832
In 1880,	68,604

Meadville, the county seat, is in Mead township, situated on the east bank of French creek (flowing south), just opposite the mouth of Cussewago creek (coming from the north and west); and its suburb, *Vallonia*, stands in the forks, on the opposite bank, in Vernon township.—Its population in 1860 was 3,702, and in 1870, 7,103‡, and it is best known for its Methodist-Episcopal and Unitarian Theological Seminaries; but it has machine works and mills, and is in business connection with the oil regions over the *Atlantic and Great Western railway*, which ascends French creek to Corry, in Erie county, (distant by rail 41 miles); and more directly by the *Franklin branch* of the same railroad, which descends French creek, and joins the Allegheny Val-

* Gray & Walling's Atlas. † Johnson's Encyc., 1876.
‡ Johnson's Encyc., 1876.

ley railroad at Franklin, in Venango county, (distant by rail 28 miles).—Level above tide (RR. station grade) 1080′.

Titusville, in the southeast corner of Crawford county, is the most important of its towns, with a population of 8,639* in 1870. It was built on the Watson flats of Oil creek, where the first oil well was bored, in 1859. It was the first center of the oil production, and is still an important site of the oil refinery.

Formerly part of Oil creek township it was incorporated as a city in 1867 and its fine City hall and numerous churches and hotels, on streets well laid out, justify the term. Its industries are all connected with the petroleum production and its inhabitants are especially busy with the manufacture of the rig and tools of oil wells, and the exchange and development of oil producing lands.

The Pittsburg, Titusville & Buffalo Railroad along Oil creek connects it with the northern railroads at Corry, distant 26 miles towards the north; and with the Allegheny Valley railroad at Oil City, distant 17 miles towards the south.

The Dunkirk, Allegheny Valley and Pittsburg Railroad ascending Pine creek (or East Oil creek) connects it with the northern railroads at Youngsville, Irvineton and Warren, distant 27, 29, and 35 miles respectively towards the east northeast.

The Union and Titusville Railroad, connects it with the P. and E. RR. at Union in Erie county, distant 25 miles towards the N. N. West.

The level of Titusville above tide, at the railroad station (grade) is 1194′ (See Report N. pp. 195, 198, 200, 204.)

Beaver Centre is a village in the center of Beaver township, in the northwest corner of the county.

Spring and *Conneautville* are two villages in Spring township, on Conneaut creek, with stations on the Erie and Pittsburg Railroad; 961′ and 1066′, grade at stations.

Summit Station on the same railroad, and *Penn line* on the Ohio State line, both in Conneaut township, are situated on the highest land in the western part of the county; 1141′.

* Bloss & Cogswell, in Johnson's Encyc., 1876.

Linesville, another station on the same railroad, is i the northeast corner of Pine township; 1033.′

Espyville is on high ground in North Shenango towı ship.

McLean's corners is another station on the E. and P. rail road, and Shenango river, in south Shenango township.

Tannersville, on the opposite (west) side of the river, i West Shenango township, is a station on the Franklin di vision of the L. S. and Mich. S. Railroad, (See *Turner*, in Re port N. page 219, 1060′.)

Jamestown is an important village on the Shenango rivei where the Erie and Pittsburg Railroad crosses it at the Mercer county line; 990′ on the F. D. and 979′ on the E. and P. RR. 42 miles from New Castle.

Dicksonburg is on Conneaut creek in Summerhill township.

Harmonsburg on high ground in Summit township.

Evansburg, on the State road, south end of Conneaut lake, Sadsbury township; RR. Station 14 miles from Meadville; 1284′.

Adamsville, west of Crooked creek, West Fallowfield township.

Atlantic (*Adamsville station*) on the A. & G. W. RR. in East Fallowfield township, 19 miles southwest of Meadville; 1148′.

Stony Point, at the great turn (southward) of the A. & G. W. RR. on the high divide between the Conneaut and Shenango waters, East Fallowfield township.

Geneva (formerly *Sutton's*) Greenwood township, on the south bank of Conneaut creek, and A. & G. W. RR. 8 miles from Meadville; 1069′.

Glenville, northeast corner of Greenwood township.

Little's corners, west of Cussewago creek, in Hayfield township.

Crossingville, on Cussewago creek, northwest corner of Cussewago township.

Mosierville, south line of same township.

Miller's on French creek, opposite (N.W.) the mouth of Muddy run, Rockdale township.

Cambridge on west bank of French creek, mouth of Little Conneautee creek, in Cambridge township.

Venango, on west bank of French creek, Venango township.

Saegertown, on east bank of French creek, at mouth of Woodcock creek (coming from the east) in Woodcock township.

Cochranton, on east bank of French creek, East Fairfield township; Franklin Branch of A. & G. W. RR. 8 miles south of Meadville junction; 1064′.

Deckard's, near the Venango county line in Wayne township.

Guy's mills, on the divide at the heads of Sugar creek and Woodcock creek, in Randolph township, 9 miles east of Meadville.

New Richmond, on the high divide between Muddy and Woodcock waters, center of Richmond township, on the State road, 12 miles E.N.E. of Meadville.

Little Cooley, at the crossing of State road and Muddy creek, west end of Athens township, 15 miles E. N. E of Meadville.

Riceville at the crossing of State road and West Branch Oil creek, southeast corner of Bloomfield township, 21 miles E.N.E. of Meadville.

Lincolnville, two miles higher up the West Branch, and near the foot of Oil Creek lake.

Spartansburg, foot of Mud lake, East Branch Oil creek, Sparta township in northeast corner of the county.

Centreville, at forks of Oil creek, west end of Rome twp.

Tryonville, on west bank of Oil creek, east end of Steuben township.

Townville, west end of Steuben township.

Troy Centre, Troy township.

Hydeville, on Thompson's run, just above its junction with Oil creek, 3 miles N.W. of Titusville.

These places can be found on the lower sheet of the colored geological map of the two counties accompanying this report.*

* By an unfortunate oversight, the railways from Titusville to Union and Corry were omitted from the Crawford county sheet.

CHAPTER II.

Topography; Railroad levels.

The mean level of the surface of the water in Lake Erie in relation to mean ocean level at Hoboken in New York harbour, has been fixed by J. T. Gardner's tables at 573.08.*

Lake Erie occupies an oval basin about 300 miles long by 60 wide; but the greatest discovered depth of water at present is only 312′. If the basin existed before the Ice Age, it must have been much deeper, to judge by the great amount of Northern Drift with which the ice sheet has covered the country to the east and south of it. At that time also it must have been an open valley or great plain through which flowed a central river fed by numerous streams, descending from the high lands of Pennsylvania, northern Ohio and western New York, through ravines in some cases walled with rock cliffs a thousand feet high. These ravines are now choked with Drift to depths of 300 and 400 feet as we learn from the well borings.†

A steep terrace of sand and clay, from 50 to 100 feet high, now lines and faces the lake, and through this terrace break three or four large streams and numerous small ones, descending from the highlands. The geological constitution of the terrace will be described further on. At Erie the rise of the bluff front of the terrace from the water to Second street is 70′; thence back to Seventy-second street there is a further rise of 120′; the city reservoir is 45′ higher still; and so the land continues to rise southwards to the general summit level of the great divide.

The Pennsylvania shore of Lake Erie is nearly straight. More precisely stated, its course from the New York line for 10 miles is 56°, for the next 6 miles 45°, and for the re-

* See Report N. p. 143 note, and elsewhere.

† See this whole subject discussed and illustrated by Mr. Carll in Report I.I.I. 1880.

maining 28 miles 64° west of south.* The bluff is equally straight. The following levels on the *Lake Shore & Michigan Southern Railroad* will show some features of the terrace.

Lake Shore & Michigan RR. (*N. table 194.*)

		Above tide.		Above lake.	Miles.
In New York.	BUFFALO,	582′	—573′=	9′	0
	Hamburg,	634		61	10
	Lake View,	708		135	14
	Angolo,	686		113	21
	Farnham,	623		50	26
	Irving,	586		13	29
	Silver Creek,	622		49	31
	Sheridan,	664		91	—
	Dunkirk,	598		25	40
	Morian's,	626		53	44
	Brocton,	688		115	49
	Portland,	694		121	—
	Westfield,	697		124	57
	Ripley Crossing,	736		163	—
	Ripley,	750		177	65
	State line,	785		212	68
In Pennsylvania.	North East,	804		231	73
	Moorhead's,	768		195	77
	Harbour Creek,	730		157	80
	Wesleyville,	697		124	84
	ERIE,	686		113	88
	Swanville,	735		162	96
	Fairview,	735		162	98
	Girard,	717		144	103
	Springfield,	663		90	108
In Ohio.	Conneaut,	651		78	115
	Amboy,	681		108	—
	Kingsville,	671		98	123
	Ashtabula,	648		75	128
	Saybrook,	650		77	133
	Geneva,	667		94	138
	Unionville,	703		130	141
	Madison,	714		141	143
	Perry,	706		133	148
	Painesville,	649		76	154
	Mentor,	650		77	160
	Willoughby,	635		62	164
	Wickliffe,	607		34	169
	Euclid,	627		54	—
	CLEVELAND,	583		10	183

The general level of the upland is given by the State road which enters Crawford county near its northeast cor-

* The long tangent of the L. S. & Mich. RR., for 14 miles west of the New York line is 56°.

ner, and runs S. 65° W. 15 miles to Little Cooley on Muddy creek; thence S. 60° W. 15 miles to Meadville on French creek; thence, average S. 60° W. 22 miles to the southwest corner of Crawford county.

The State road runs therefore in nearly a straight line for 52 miles, parallel to the shore of lake Erie, and about 30 miles to the south of it. It was leveled by Mr. Carll through Warren and Crawford and the following list of *elevations above ocean*, where it crosses the *streams* and *divides* is made from his profile section plate 3 A in Report I.I.I. 1880.

State road levels.

		Ocean.		*Lake Erie.*	*Miles.*
In Warren County.	Sugar Grove,	1380′	—573′=	807′	45½
	Pike's rocks (XII),	1980		1417	41½
	Little Broken Straw creek,	1357		784	39¼
	Divide,	1795		1222	——
	Deadman's run,	1619		1046	37½
	Divide,	1954		1381	——
	Miles run,	1830		1257	36½
	Divide,	——		——	——
	Blue Eye run,	1580		1007	35½
	E. edge of divide,	1830		1257	35
	Big Brokenstraw creek (RR.),	1392		819	33
	West Spring creek village,	1457		894	30
In Pennsylvania.	County line,	1653		1080	28
	Divide,	1690		1117	27
	Divide,	1797		1224	26¼
	Oil creek, (RR.),	1430		857	24¼
	Divide,	1605		1032	23
	Britain run,	1360		787	21¾
	Divide,	1621		1048	20¾
	Riceville,	1315		742	19
	U. & T. RR.,	1369		796	18½
	Divide,	1611		1038	17¼
	Cross roads,	1602		1029	16
	Divide,	1617		1044	15½
	Muddy creek, Little Cooley,	1210		637	13¾
	Divide,	1428		855	12
	New Richmond,	1312		739	10½
	Divide,	1581		1008	9
	Woodcock creek,	1247		674	7½
	Divide,	1435		862	6¼
	Divide,	1361		788	4½
	Branch of Woodcock creek,	1397		824	3
	Divide,	1550		977	1½
	Meadville,	1080		507	0

Evansburg is 8 miles west of Meadville, and levels taken (going west) in a length of 6¼ miles were as follows:

Miller's quarry,	1,303	730	——
Evansburg (RR.),	1,284	711	——
Mushrush coal,	1,324	751	——
McEntire coal hill,	1,338	765	——
Unger hill,	1,348	775	——
Run,	1,240	667	——
McLanahan quarry,	1,315	742	——
Run,	1,277	704	——
Hazen's hill,	1,443	870	——
The highest divide between Adamsville and Jamestown, 4 miles south of the State road, was at Snodgrass ore bank,	1,360	787	——
Crooked creek, at Adamsburg,	996'	423	——
RR. at Jamestown,*	987	414	——
Midway in Mercer Co.,	1,083	from Oil City,	48.6
Jamestown,	990		51.1
Turner,	1,060		54.2
Simond's,	1,057		57.2
Andover,	1,095		62.8
Richmond,	*1,114*		——
Dorset,	988		70.4
Ashtabula,	648		87.2

It is evident then that the highest land along the State road is at the eastern end of Crawford county, and that the general level falls off westward; for the *divides* read: *above Lake Erie*, 1417, 1222, 1381, 1257, 1117, 1224, 1032, 1048, 1038, 1044, 855, 1008, 862, 788, 977 as far as Meadville; and 730, 765, 775, 742, 870 as far as Hazen's hill, 5 miles west of Evansville; and 787 between Adamsville and Jamestown, in the south-west corner of the county.

This expresses the law of the topography of the region: a steady decline in the height of the uplands from the State of New York through Pennsylvania into Ohio.

The same law is exhibited by the drainage of the region, as will appear from the map; thus: The head waters of French creek are partly in New York State, partly in the extreme eastern township of Erie county, and partly along the high divide which overlooks the Lake at an average distance of 10 miles back from the shore.

The flow of the French creek waters is down the dip of the

*The Franklin Branch of the Lake Shore and Michigan railroad runs across the extreme corner of the county here, and its levels are:

measures from north southward, and down the general slo of the surface from north-east south-westward. At Mea ville, French creek turns and cuts down through the upp measures (with the dip) south-eastward.

The level of the valley bed in which the South Branc and main stream of French Creek flows is shown in the fo lowing table of the Atlantic and Great Western Railroad from Corry to Meadville; and in the table of the Frankli branch of the same from Meadville Junction down the creel to Franklin, on the Allegheny river.

Atlantic and Great Western Railroad.

	Ocean.	*Lake.*	*Miles*
Salamanca, in New York,	1393—573=820		0
Bear Lake, in Warren county,	1550	977	51
Columbus, in Warren county,	1427	854	58
Corry, in Erie county,	1431	858	61
Concord station,	1361	788	—
Union City station,	1301	738	72
Mill Village station,	1216	643	79
Millers station,	1169	596	85
Cambridge station,	1163	590	88
Venango station,	1163	590	92
Sægertown station,	1116	543	96
Meadville station,	1080	507	102
Franklin Branch Junction,	1074	501	105±
Shaw's Landing station,	1092	519	108±
Cochranton station,	1064	491	113±
Carlton (Evans' bridge),	1047	474	116±
Utica station,	1035	462	121±
Sugar Creek station,	1014	441	126±
Franklin station,	987	414	130±

From the Junction westward the At. & G. W. RR. crosses the divide to the Shenango and descends that valley southward to the Ohio river; its levels are as follows:

	Ocean.	*Lake.*	*Miles.*
Meadville Junction,	1074—573=501		—
Geneva (Sutton's),	1069	496	110
Evansburg,	1284	711	116
Adamsville,	1148	575	121
Sugar Grove (Mercer county),	1040	467	—
Greenville, " "	984	411	129
Shenango, " "	936	363	—
Transfer, " "	993	420	135
Orangeville, " "	945	372	141
Ohio State line, " "	945	372	—

The descent of Oil creek waters from the high divide of Crawford county south of French creek, with the dip, may be seen in the southeastern quarter of the map, and is illustrated by the following tables of levels:

Union and Titusville Railroad. (*N, Table 177.*)

	Ocean.	Lake.	Miles.
Union City, { A. & G. W. depot,	1301—573=	728	92
Union City, { P. & E. depot,	1270	697	92
Mile-post,	1339	766	91
Mile-post,	1376	803	90
Mile-post,	1414	841	89
Near Summit,	1458	885	88
Mile-post,	1431	858	87
Mile-post,	1407	834	86
Mile-post,	1406	833	85
Lakeville,	1412	839	84½
Mile-post,	1399	826	84
Lincolnville,	1382	809	83½
Mile-post,	1382	809	83
Mile-post,	1381	808	82
Riceville,	1369	796	81¼
Mile-post,	1357	784	81
Mile-post,	1307	734	80
Mile-post,	1307	734	79
Mile-post,	1291	718	78
Noble's,	1298	725	77½
Mile-post,	1287	714	77
Mile-post,	1315	742	76
Tryonville Junction,	1320	747	76
Titusville,	1194	621	67
Oil City depot,	1008	435	50

Pittsburg, Titusville & Buffalo RR. (*N, table 172.*)

	Ocean.	Lake.	Miles.
Corry, depot,	(1427)—573=	854	94.4
Mile-post,	1458	885	93
Culvert, 92—40′,	1481	908	92
Culvert, 91—60′,	1499½	926	91
Culvert, 90+1600′,	1555	982	90.3
Mile-post,	1586	1013	90
Mile-post,	1633	1060	89
Summit, 89—1800′,	[1646½]	1073	88.7
Trestle, 88—150′,	1593	1020	88
Mile-post,	1509	936	87
Trestle, 87—1000′,	1499½	926	86.8
Trestle, 86—500′,	1456½	893	86.1
Spartanburg trestle,	1453½	890	—
Culvert, 84+950′,	1429½	856	84.2

	Ocean.	Lake.	Miles.
Mile-post,	1426	853	84
Culvert, 83+130′,	1377	804	83
Culvert, 82+160′,	1352	779	82
Culvert, 81+460′,	1339	766	81.1
Mile-post,	1326	753	80
Culvert, 79+100′,	1324	751	79
Culvert, 78—100′,	1296	723	78
Mile-post,	1304	731	77
Mile-post,	1316	743	76
Mile-post,	1296	723	75
Mile-post,	1284½	711	74
Mile-post,	1268½	695	73
Mile-post,	1243	670	72
Mile-post,	1248½	675	71
Howe truss bridge, S. end,	1254	681	—
Mile-post,	1237	654	70
Mile-post,	1220	647	69
Mile-post,	1206	633	68
Titusville. Munroe street,	1195	622	67.5
Titusville. Washington street,	1194	621	67.3
Titusville. Franklin street,	1194	621	67.1
Mile-post, (up Pine creek),	1200	647	67
Mile-post,	1215	672	66
Mile-post,	1199	626	65
Mile-post,	1177	604	64
Mile-post,	1153	580	63
Mile-post,	1132	559	62
Mile-post, and so on to	1134	561	61
Oil City, Centre street,	1010	435	50.2
Oil City, Bridge, S. end,	1014	441	—

Although Oil creek waters now flow southward into the Allegheny river at Oil City, Mr. Carll believes that there was a time, previous to the great change in the surface of the region made by the Northern Ice when it turned at Tryonville westward and used what is now the valley of Muddy creek, joining French creek at Miller's.

This is the proposed route of the Pennsylvania and Petroleum Railroad, the preliminary survey of which shows the following levels:

Penn. and Petroleum R. R. (*N, table 178*).

		Ocean.	Lake.
TITUSVILLE,	on Oil creek,	1181	608
Newton's Mills,	on Oil creek,	1258	685
Athens Mills,	on Oil creek,	1266	693
Little Cooley,	on Oil creek,	1203	630

	Ocean.	Lake.
Teepletown,	1204	631
Cambridge, on French creek,	1158	585
Edinboro' (Lake Conneautee),	1212	639
Summit (over to Lake Erie),	1278	705
McKean's Corners,	1053	480
ERIE,	573	0

In like manner, according to Mr. Carll, French creek in pre-glacial times—before its lower water course was filled with Drift, and its waters first spreading out into a great upland lake over northern Crawford and southern Erie counties, cut for themselves a new channel southward through the barrier above Franklin—turned sharply westward below Meadville up Conneaut Lake creek into Lake Erie. I cannot, however, yet accept Mr. Carll's conclusions; for, in my opinion French creek has always drained southward into the Ohio river.

No railway line follows this route the entire distance; but some of its features are illustrated by the levels of the Pittsburg and Erie railroad, which runs north and south, not very far from the Ohio State line. It ascends the Shenango river from the South as far as McLean's Corners (in the southwest corner of Crawford county); then crosses the broad flat of the Pymatuning swamp district; then crosses the Great Divide, by Linesville and Summit Station, and descends the west slope into the valley of Conneaut creek, which it follows down to its great bend 6 miles from the lake shore, and so descends to Girard Junction on the Lake Shore railroad.

Pittsburg and Erie railroad. (*N, table 191.*)

	Ocean.	Lake.	Miles.
Girard Junction,	697—573=	124	83
Crosses,	765	192	78
Albion,	857	284	72
Spring,	961	388	66
Conneautville,	1066	493	63
Summit Station, on the Grand Divide,	*1141*	*568*	*59*
Linesville,	1033	460	55
Espyville,	1088	515	51
Kasson's,	1111	538	49
Jamestown,	979	406	42

	Ocean.	Lake.	Miles.
Greenville,	961	388	35.5
Shenango,	941	368	34
Newcastle,	809	236	0
Beaver, on the Ohio river, (*R. R.*),	710	137	—

By this route the Grand Divide is crossed at an elevation of 568′ above Lake Erie, and at a point about 25 miles south of the lake shore.

On the Philadelphia and Erie road the summit grade on the Grand Divide is 657′ above Lake Erie, and about 8 miles *in an air line* south of the lake shore; as appears from the following table:

Philadelphia and Erie RR. (*N, Table 129.*)

		Ocean.	Lake.		Miles from Philadelphia.
Erie,	Lake Water,	573	0		
	RR. Depot,	584	11	288	0
	L. S. & M. RR.,	687	114	—	
Belle Valley,		1007	434	281	7
Langdon's,		1135	562	279	9
Jackson's, on the Grand Divide,		*1230*	*657*	*275*	*18*
Waterford,		1193	620	269	19
Le Bœuf,	Ascending S. branch of French Creek,	1217	644	265	23
Union,		1270	697	262	26
Concord,		1384	811	256	32
Lovell's,		1364	791	254	34
Corry,		*1427*	*834*	*251*	*37*
Columbus,	In Warren Co. descending the Broken Straw waters.	1401	828	249	—
Spring Creek,		1395	822	244	—
Garland,		1308	735	238	—
Pittsfield,		1244	651	234	—
Youngsville,		1211	638	230	—
Irvineton,		1172	599	228	—
Warren,		1186	613	222	—

Much higher land, however, than the summit crossing of the P. and E. R. R. lies along the Great Divide both to the east of it, and especially after passing into the State of New York; as is shown by the following table of the levels along the railway from Corry north to the Lake Shore at Brocton:

Buffalo, Corry and Pittsburg R. R. (*N, table 179a.*)

	Ocean.	Lake.	Miles.
Brocton Junction, N. Y. (Lake Erie),	672—593=	99	42
Prospect,	1221	658	34
Mayville,	1300	727	28

	Ocean.	Lake.	Miles.
Summerdale, on the Grand Divide,	*1629*	*1056*	*22*
Sherman,	1568	995	18
Panama,	1545	972	12
Clymer (Brokenstraw valley),	1146	573	8
State Line,	1417	844	8
Childs,	1474	901	—
Corry Junction,	1423	850	0

The summit at railroad grade along this road is (1,619′ A. T.) 1056′ above lake Erie; but the top of the hills in which appear the great Panama Conglomerate rise to (1880′) 1307′ above the Lake, and these hill tops mark the line of the Great Divide as it runs and rises eastward through southern New York.

Lake Chautauqua in New York is 726′ above lake Erie; its head only 7½ miles (air-line) distant from the shore; hill tops west of it rise to 1056′; others east of it to 1177′ above the lake.

Cassadaga Lake, still further north-east, 732′ above lake Erie, distant 7½ miles, is enclosed by equally high land.

Still further east the rock cities of Salamanca and Olean in New York rise to 1677′ and 1727′ above the lake; and the whole of the country through which the upper Alleghany river flows is very high.*

The characteristic topographical features, then, of the region of Erie and Crawford counties may be thus described:

From the brow of the Lake Erie sand-bluff terrace there is an *upward slope* to a line which may be drawn on the map from the north-east corner of Greenfield township, Erie county, on the New York State line, 11 miles south of the lake shore,—through Greene, Summit, McKean, Franklin, Elk-lick, and Spring,—to the north-west corner of Conneaut township, Crawford county, on the Ohio State line, 23 miles south of the lake shore; a line running S. 53° W. the average direction of the lake shore being 60°.

Down this slope flow many small streams—Raccoon and Crooked creeks near the Ohio line; then Elk creek and its southern branches, South branch, Falls, Goodban's, and Lamson's runs; then Trout run, Bear run, and the other

* See the Map of Drainage in Report I.I.I, 1880.

upper runs of Walnut creek; then Mill creek at Erie; finally Crowley's run, Six Mile creek, Elliott's run, Scott's run, Twelve Mile creek, Sixteen Mile creek, Averill run, and Twenty Mile creek, at the New York State line.

The slope is high and short at the New York line, long and low at the Ohio line. Consequently the *long* streams descending from the divide to the lake are all west of Erie; all the streams east of Erie are short and rapid.

Walnut creek is 15 miles long, and yet its head is only 8 miles back from the lake shore.

Elk creek is 25 miles long (by its bed), and yet its head is only 10 miles back from the shore.

Conneaut creek runs 26 miles in Pennsylvania before crossing the Ohio line, and its southern source is 22 miles back from the lake shore.

The course pursued by these streams is always the same, viz: first down the upper part of the slope towards the lake; then westward, in a deep gully, with rock walls, parallel to the lake; then out through a ravine straight to the lake shore.

The cause of this curious phenomenon, as it seems upon the map, is very simple, viz: the flattening of the high land southwestward; and the general dip of the formations in the same direction.

In the eastern townships of Erie, the hills and table lands often rise to *1000′ above the lake level;* and in Wayne and Concord (next to Warren county), to *1200′* and even more.*

West of French creek the whole upland is so reduced that few of the hilltops exceed *875′ above the lake level.*

West of the Conneaut and Conneautee there are no hill tops higher than *725′ above lake level;* and along the Ohio line the country seems to have a nearly uniform elevation (broken only by the valley beds) of about *500′*, and no hills of any consequence are to be seen.

The *eastern* streams descending to the lake have a short fall from the divide twice as great as the long fall of the

*See tables of barometric heights in the description of the townships in Part Second of this Report.

western streams. But the slope which they descend is also steep, so that they have excavated regular sloping vales.

The *western* streams, on the contrary, cut down into what is really a sloping table-land, deeply in their upper courses; and therefore flow for miles in ravines, or cañons, between cliffs of nearly horizontal strata.

The French creek waters, flowing south from the divide present a wholly different topographical phenomenon; Spafford's run and the North Branch on the New York line; Lake Pleasant and its outlet; LeBœuf creek and its two head branches, east and west; Little Conneautee creek; Conneautee lake with its creek; Torry and Stewart's runs; Cussewago creek with its three head branches; Wasson's run, and Conneaut lake with its feeders and outlet creek, drain the whole rain-fall of the great divide southward, through flat valleys, one and even two miles wide, bordered by low and gently rounded hill slopes, and separated by low flat table lands.

Crooked creek and the headwaters of Shenango river, draining Pymatuning swamp in two opposite directions, but all the waters finding their way southward, emphasize the same style of topography in the southwest corner of the region.

Lakes and *swamps* are of course numerous in such a country, so flat, and so entirely covered with the great bowlder clay and gravel deposit of the Northern Ice Drift.

Lakes Pleasant, Le Bœuf and *Conneautee* lie on a line north of French creek in Erie county.

Oil creek lake and *Conneaut lake* lie on a parallel line diagonally drawn across Crawford county.

Sugar lake lies near the Venango county line in Wayne township.

Conneaut swamp represents the former extension southward of Conneaut lake when it was much larger than at present, as is shown also by swamps at the northern end of the lake. It stretches along Conneaut lake creek to within 2½ miles of its junction with French creek, and was estimated at 5000 acres by the State Surveyor General. Much

of it has been reclaimed, however, by deepening and straightening the creek. The lake itself might be drained by the same process. The vegetation of the swamp consists of Swamp willow (*Salix longifolia*), Tamarack, Black alder (*Alnus rubra*), Witch hazel, Poison sumach, &c., and the Side Saddle Flower, (*Saracenia purpurea*) may be found in it. In the standing water pools nothing grows but the Broad leaved flag (*Typha latifolia*).

Pymatuning swamp represents a large lake which formerly existed in the southwest corner of Crawford county. It extends from the head of Crooked creek near Hartstown, along the Shenango, 15 miles, to the Ohio State line, with an area of 9000 acres (in 1868, when surveyed by Col. Worrall,) now considerably reduced by judicious ditching and draining. It lies 1025′ above tide, or *452′ above Lake Erie.*

Tamarack swamp stretches across the water shed of the Great Divide in Erie county, on the highest land of the Waterford-McKean township line, joining the sources of Elk and Conneautee creeks.

Swamps occur along the south branch of French creek, but elsewhere in Erie county they are rare, on account of the greater slope of the ground. But in Crawford county they are numerous enough.

A large swamp covers the southern and eastern portions of Randolph township; and others exist in Troy, Athens and Bloomfield.

It only remains to note certain peculiarities of the individual water courses of the region, as follows:

Conneaut creek heads on the Drift-filled low divide of Summit township, Crawford county, (an extension of the Conneaut lake basin northwards,) and runs north—between low banks of quicksand and gravel upon a Drift-filling sometimes 180′ deep (as shown by borings,) receiving many short tributaries on both sides, and one large one, the West Branch, from Ohio—17 miles, to within 6 miles of the lake shore.

Here it makes a right angle west and flows parallel to the lake shore into Ohio. A map of Ohio will show it

doubling back east to within 2 miles of the State line and then entering lake Erie. Its barometric levels are as follows:

	Ocean.	*Lake.*
Conneaut creek head divide,	1100′	527′
Dicksonburg,	995	422
Conneautville,	920	347
Spring,	870	297
Albion,	815	242
Cherryhill vicinity,	785	212
Ohio State line,	770	197
Mouth,	573	0

From Dicksonburg to Albion is 12 miles in air line, and the fall is 180′ = 15′ per mile.

No rock in place is visible above Conneaut V.; but Chemung flagstone strata are frequently exposed between the bend and the State line.

Raccoon creek is short and flows in Drift, but the top of the Portage strata is exposed at its mouth.

Crooked creek is like Raccoon creek in both respects.

Elk creek, is a large stream, with many south side runs. It heads in Tamarack swamp; flows west, with large oxbow bends near Girard, and then northwest into the lake. It cuts down into the rocks early in its course, and from Middleborough downwards offers the finest rock exposures of Oil Sand Group, Chemung flags, Girard shales, and upper Portage in the county, every inch of these formations being distinguishable. The scenery is picturesque and sometimes wild. For a long distance above Girard the stream flows through a narrow gorge between walls of Girard shale 100′ high. Its barometric levels are as follows:

	Ocean.	*Lake.*
Tamarack swamp, *on the Grand Divide,*	1250′	677′
O. Dunn's, 2 m. above Middlebo',	1085	512
Middleborough (McKean Corners),	1010	437
V. Baron's, 1½ m. below Middleborough,	990	417
Swallew's mill,	850	277
Fall's run mouth,	800	227
Girard,	635	62
Mouth at lake Erie,	573	0

For two miles above Middleborough the rate is 38′ per mile. From Middleboro' to Girard (10 miles air line), 37½′ per mile in air line; but by water course (15+miles) only 25′ per mile.

Walnut creek rises at the P. & E. RR. line, and flows west parallel to and between Elk creek and the lake shore. Fine rock exposures, especially of Girard shale, form vertical cliffs of 50′ and 75′. At Bear's run, near Swanville, it cuts down to the Portage rocks, and then descends rapidly to the lake. Its barometric levels are as follows:

	Ocean.	*Lake.*
Water shed, or *Grand Divide*,	1275	702
Smith's mill,	935	362
Butt's mill,	850	277
Gudtner's mill,	700	127
Bear's run mouth,	675	102
Mouth at Lake Erie,	573	0

Its bed being about 15 miles long, its rate of fall averages 47′ per mile.

Mill creek, at Erie, flows westward at first, but with two great bends, along the northern edge of a wide level area 1000′ above tide, or 427′ above Lake Erie.* Its course is often extremely wild, and its rate of descent is 100′ per mile, through a narrow gorge, heading in Middle Chemung strata, cutting down through Girard shale, and finally exposing 200′ of Portage rocks.

Crowley's, Six Mile, and Elliott's runs, all small and rapid, expose Chemung and Girard rocks, and more and more of the Portage series.

Twelve Mile creek heads 7 miles south of the shore, in the outcrop of the Third Oil Sand, (1475′) *902′ above lake level*, and falls at the rate of over 100′ per mile, exposing the lower Chemung, Girard, and Upper Portage rocks, in vertical walls a hundred feet high.

Sixteen Mile creek has numerous head runs in New York State, and pours a copious stream through a deep gorge of Girard and Portage cliffs.

Twenty Mile creek pours more water into Lake Erie than any of those before mentioned except the Conneaut. Its mouth is 1½ miles from the New York State line, and most

* It looks as if this had once formed part of an ancient shore line.

of its water-courses are in that State. It shows 450′ of Portage rocks, in a striking cañon with vertical cliffs 150′ high. Where this profound ravine passes the State line it is known as "the Gulf," a favorite place for picnic and pleasure parties.

Shenango river drains out of the north end of Pymatuning swamp and circles inside the Ohio State line to flow south into Mercer county. *Paden's* (*Peyton*) *run* and others enter it from the north, at the west end of the dismal morass. The amount of water leaving Crawford county by this channel is small.

Crooked creek, draining the south end of Pymatuning swamp, flows straight south into Mercer county and joins the Shenango at Greenville. A ridge 300′ high separates these streams. The valley of Crooked creek is wide and flat, and filled to a great depth with Drift. The stream is sluggish and meandering and was followed by the old deserted Beaver and Erie canal. *Little* and *Mud* lakes are merely small open water places in the marsh.

Conneaut Lake creek drains Conneaut lake eastward sluggishly through a marsh for eight miles, and flows 2½ miles further to French creek.

Conneaut lake, 2¾ miles long and less than a mile wide, on the low divide between the French creek, Conneaut and Shenango waters, was made a reservoir for the old Beaver and Erie canal, by a 10′ dam across its outlet. Its volume was increased by means of a branch canal feeder brought from a dam on French creek above Meadville. This feeder was engineered down French creek, east bank, across French creek on an aqueduct, and up the north side of the valley of Conneaut Lake creek. Reservoir surface level, 1082′= *509′ feet above Lake Erie.*

A natural embankment or moraine of Drift, 15′ to 20′ high, lies across the valley at Glendale, and forms a natural dam to the marsh, which extends up to the foot of the lake. Marshes extend three miles north of the head of the lake.

The ancient lake behind the moraine was therefore at least 14 miles long, or about the size of Lake Chatauqua in New York. Under the present peat bogs of the swamps lie old deposits of fresh-water shell-marl.

The natural creek way through the moraine has been recently deepened and the canal abandoned. The lake level is now only 1070′=*497′ above Lake Erie.*

Cussewago creek flows 15 miles south and then 3 miles east into French creek, at Meadville; sluggish and meandering along a wide shallow Drift-filled valley, the side-hills of which, however, often rise abruptly from the plain; showing thus, incidentally, how deep the Drift must be in this pre-glacial valley bed.

Conneautee creek descends from the Divide into *Conneautee lake* (1¼ m. long by ½ m. wide), decked with white water lilies (*Nymphæa*); issuing from which it traverses a wide level plain, receives Torry run, and enters French creek.

Little Conneautee creek enters French creek, at Cambridge.

Le Bœuf creek has two wide spreading east and west branches on the high divide, both heading within 7 miles of the lake shore. It flows sluggishly southward, and spreads into *Lake Le Bœuf*, at Waterford (¾ m. long and ½ m. wide), *Black run* coming in at the foot of the lake from the west. *Tamarack swamp*, at the head of Trout run or the West Branch, has already been described.

French creek North Branch heads in Greenfield township, so far as five small streams descending from the great divide is concerned, but its extreme eastern headwaters are over the New York State line. The main stream flows six miles S. W. through Greenfield;—then down the slope S. S. E. six miles (air line) through Venango township (with two considerable bends) to Wattsburg (where *Spafford run* comes in from the east);—then S. W. 6 miles to the Waterford line;—then 3 miles S. to the P. & E. RR. bridge, where

the *South Branch* joins it from the east;—then 4½ m. W., with many meanders, to the mouth of *Le Bœuf creek;*—then 6 miles S., with many meanders, to Millers, at the mouth of *Muddy run*, coming from the southeast;—then 5 miles W. with meanders, past Cambridge and *Little Conneautee creek* to the mouth of *Conneautee creek;*—then 7 miles S. S. W. past Venango to Sægertown, at the mouth of *Woodcock creek*, coming in from the east; then 5 miles (air line) S. with two great bends, to Meadville, at the mouth of *Cussewago creek;*—thence in a wide gentle curve, with a chord of 10 miles S. S. E. to Cochranton, at the mouth of *Little Sugar creek;*—and S. 2 miles further into Venango county.

The fall of French creek is gentle, as will be seen 1, by its meanders, and 2, by the following barometric and other levels:

	Ocean.	*Lake.*	*Miles.*	*Rate.*
Watershed on the *Great Divide*,	1500′	927′	—	1′
Greenville (vicinity),	1400	827	3	33′
Wattsburg,	1315	742	7*	12′
Doolittle's run mouth,	1310	737	3	1½′
Waterford line,	1235	662	2	37′
South Branch mouth,	1200	627	3	12′
(Carroll's quarries,	1190	617)		
Millvillage bridge,	1165	592	5*	7′
Opposite Miller's RR. station,	1135	562	3	10′
Cambridge (water),	1130	557	4	1¼′
Venango (water),	1115	542	2½	10′
Sægerstown (water),	1100	527	4	1′
Meadville (water),	1065	492	5½	6′
Cochranton (water),	1050	477	10	1½′
Crawford-Venango line (water),	1045	472	2¼	1′
Utica (Venango county), (water),	1020	447	6	4′
Franklin; Allegheny R. (water),	970	397	9	5½′

French creek is very irregular in its fall, as seen from the above table; but if the bends and numerous meanders were considered, the more rapid rates would be greatly reduced.

From the watershed to Greenville,	the rate is about	33′	per	mile.
From Greenville down to Wattsville,	"	9′	"	"
From Wattsburg to the Forks,	"	14′	"	"
From the Forks to Franklin (60 miles),	"	4′	"	"

The South Branch rate from Concord to Union (4 miles)

* Air line across a wide bend.

is only 3½′ per mile, but its northern affluents *Beaver run*, *Slaughter's run*, *Baskin's run*, and *Spencer's run* descend from the highlands at a maximum rate of 60′ per mile. *Lilley run*, coming in from the highest land in the region in Concord township has a still higher rate.

The head run of the South Branch, from which it gets its name, runs due north, from a deep cut at the head of Oil creek, and reaches the valley bed a little west of Corry. This cut is through the high divide of Concord and Sparta townships, and will be described further on.

Muddy creek flows in an ancient valley of erosion, now filled deep with Drift. The stream meanders sluggishly between banks of quicksand and gravel northwestward for 12 miles, receiving *Federal run* and *Kelley's run* from the north and other runs from the south, and joins French creek at Miller's.

Woodcock creek, with its head at Guy's mills in the center of Randolph, flows 5 miles due north, and then 9 miles nearly due west to French creek at Saegertown.

Sugar creek West Branch probably flowed northwestward through the flat divide along the present Woodcock channel, in preglacial times. When this channel was filled by the ice with Drift a lake was formed and a new outlet was cut southward in the direction of Franklin and the Allegheny river.* The greatest quantity of Drift was dumped into the valley about Guy's mills, where the surface is now about 40′ higher than the streams. *Guy's run* once flowed into Woodcock creek; but a few years ago a ditch 3′ deep sufficed to turn the run into Sugar creek. The water plain of the valley is a mile wide; the bordering hill-slopes rise abruptly from it to a height of 200′.

Six miles lower down, the stream spreads into an oval lake (*Sugar lake*) a mile long, and half a mile wide, and only from 16′ to 18′ deep. Forty years ago it was more than 30′ deep. The clearing of the upland slopes is rapidly filling it with sand and mud.

Sugar creek East Branch heads in like manner in the Drift-filled valley plain around Townville and possibly once poured its waters northward down Muddy creek.

* According to Mr. Carll.

Little Sugar creek has two north branches each heading similarly in Drift-plain valleys on a level with the heads of runs flowing northward towards Meadville and Sagerstown.

Oil creek drains all eastern Crawford county southward into the Allegheny river. In preglacial times, before the rock gate at Titusville was opened, all the *Pine creek* waters of Warren and Venango county flowed past Titusville along the present channel of Oil creek northwestward, and being joined first at Hydetown by *Little Oil creek* and *Thompson's run*, and then near Tryonville by the *East and West Branch* waters, poured along the channel of Muddy into French creek; the present water shed west of Tryonville being merely a slight elevation in the Drift-plain of the ancient valley.* (Carll.)

The northern feeders of Oil creek—*Mosey run* entering the west branch at Lincolnville, *Negus run*, entering at Riceville, *Britain run* and two others entering the east branch, above Centreville, where the two branches unite—descend southward from the Concord-Sparta-Bloomfield highlands with its maximum hill-tops of 1850′ above tide. The fall by Mosey run to Riceville (1315′) is 400′ or 500′ in 9 miles; Negus run falls as much in 4½ miles.

Oil Creek Lake, between the two, is 2 miles long and ¾ mile wide, fed by two runs descending from the highlands, and also by numerous springs which rise from its bottom and sides. Its beauty makes it a place of great resort.

The valley of Oil creek is wide and flat, and the hills rise abruptly and often with cliffs from its flood plain, showing that its ancient bed lies far beneath the present surface. In fact the Grey well, six miles above Titusville, has a drive pipe 226′ long.

The following levels of Oil creek will show its present rate of descent:

	Ocean.	*Lake.*	*Miles.*	*Rate.*
Oil creek lake,	1389′	816′		
Riceville (water),	1325	752	1¼	50′+
Centreville (water),	1275	702	3¼	13′+
Tryonville (water),	1260	687	8	5′+
Road, N. E. corner of Troy T.,	1250	675	—	—

* For Mr. Carll's argument see Report I.I.I. Chapter 32, p. 356, 1880.

	Ocean.	Lake.	Miles.	Rate.
Hydetown (water),	1230	657	5*	6′
Titusville (water),	1160	587	3½	20′
Oil city (water),	985	412	17	10′

Big Brokenstraw creek merely crosses the northeast corner of Wayne township, Erie county; but its branch, *Hare creek* carrying the little *Bear creek*, takes a sweep of seven miles, north and east of Corry.

Spring creek of Warren county also heads just inside Crawford county in Concord township.

CHAPTER III.

Surface Geology.

Soil, Drift, Erratic Bowlders, Buried Valleys, Terraces, Peat, Shell-Marl.

The soils of the district, while they often yield bountiful crops, are eminently adapted to grazing, and can be most successfully employed for such purposes. Dairying and the rearing of stock find here as profitable returns as in the Western Reserve of Ohio, of which this region is, in fact, a continuation eastward.

There are two principal classes of soils; one, derived from the decomposition of Drift material; the other, originating in the decay of vegetable matter in the vicinity of bogs and land reclaimed from swamps. Few localities exhibit a soil derived wholly from the decay of rocks *in situ*.

From the Drift there generally results a strong clayey or sometimes gravely soil, rich in fertilizing elements; but owing to the impervious bed of clay which so often accompanies the Drift, this soil is generally inclined to be cold and wet, so that the land has to be thoroughly underdrained before first-class crops can be raised.

The swamp soils of course require draining before farm-

*In an air line.

ing, but when properly drained and cleared up they possess almost inexhaustless fertility.

The deep covering of decayed vegetable mold found in such large quantities in every bog within the district would make an excellent top-dressing for the colder clay soils derived from Drift; and the attention of farmers cannot be too strongly called to this valuable source of manure for their lands, procurable at a slight cost and in vast quantities.

Drift. There is little land within the district under review that has not been affected by the great ice-sheet which in glacial times moved southeastward over the entire region of Erie and Crawford counties, except, perhaps, one small area which rose high enough to be an island in the sea of ice.

The highest point at which I have found evidence of glaciation is 1750′; but there are hill-tops of 1850′ at the eastern end of Erie county on which I could not find any Drift or erratic bowlders.

I do not regard this negative evidence as very conclusive, however, since I could not examine all the summits; and it is possible that the long continued erosion of the surface has obliterated the originally thin coating of Drift left at such an elevation. The distribution of the Drift in the counties to the east seems to fix the upper limit of the ice at about 1750′. Large tracts of Warren and Forest counties, from 1800′ to 2000′ above tide, afford no evidence of having ever been covered, although the exposed rocks are such as would have retained scratches.

While the ice was smoothing down the lower flat country of the western townships it was operating through the deep and narrow vales of the eastern counties, leaving the high hill tops comparatively untouched.

At Meadville I found glacial scratches upon the upper surface of the Sharon Conglomerate which forms the top of College hill, 1550′ above tide, *1177′ above Lake Erie*, and 500′ above the present bed of French creek, which is at least 300′

above its old water course beneath the Drift. The ice therefore must have been at least 800′ thick here.*

The direction of the ice grooves which I observed on thirty or forty summits in the two counties has been uniformly about S. 30° E., or South-south-east.

The greatest thickness of the ice sheet, thus moving from the N. N. West, must have been over the low lying western townships, and its thin melting edge over the eastern townships, around and between hills formed or capped by harder rocks than those of the lower lands.

The varied character of the Northern Drift deposits can be well studied along the shore of Lake Erie, towards the Ohio State line, where they constitute a terrace bluff, from 50′ to 80′ high, out of which the waves are constantly removing the clay and fine sand into the lake, leaving the coarse sand, pebbles and bowlders to be daily rounded and polished on the beach. Stratified rocks are scarcely anywhere exposed along the shore west of Erie, except at the mouths and in the beds of inflowing streams.

The matrix is a bluish-white tough clay imbedding fragments, mostly angular, of all kinds of crystalline rocks, with sandstone, shale, black slate and limestone; and occasionally a large bowlder of granite or gneiss is seen protruding from the mass.

Quicksand is abundant in the Drift deposits of the townships back from the lake, and especially along the summit level of the Beaver and Erie canal. A bed of it 2′ thick was found in cutting the channel for the canal; and for a mile and a half the sides of the canal had to be timbered and boarded.

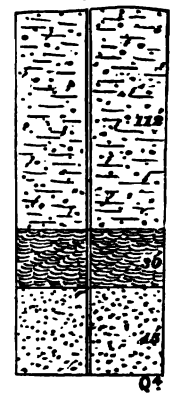
Along the depression of Conneaut lake the Drift is probably very deep, but I could hear of no borings. Conneaut creek valley is heaped with Drift from the summit down to the great bend.

Mr. Schofield, who is a very reliable citizen of Conneaut-

* On the supposition that the old buried channel was already that deep previous to the invasion of the ice. But we are wholly ignorant of the *eroding ability* of such ice, in such a country and under such circumstances.

ville, and who drilled the well himself, gave me the following record of a drill-hole near Conneautville: Fig. 1.

1.



Near Conneautville.

Drift,	Gravel, bowlders, clay, &c.,	112′
	Shale and sand layers,	30′
	Quicksand,	45′
	Bed rock and top of drill hole, at	187′

Mr. Scofield informed me that after drilling through 30′ of what was supposed to be bed rock, the tools dropped, and quicksand "boiled up like mush." The drive-pipe had to be extended to 187′. The apparently stratified shale must be part of the Drift deposit, and the 30′ of shale may possibly be an immense erratic; or perhaps a projection of the valley wall, undercut on one side, and filled beneath with quicksand.

This quicksand deposit is highly interesting, although others of less size lying between stratified rocks have been bored through elsewhere.

The Drift in French creek valley is very deep. About 4 miles below Meadville, a drive-pipe was put down 285′ without touching bottom rock; all the way through quicksand and bowlders.

The Drift on Oil creek is shown to be 100′ and 200′ deep, by well borings.

On Muddy creek the water wells are dug in quicksand, and heaps of Drift are to be seen everywhere on the surface.

But on the high lands there seems to be but a thin coating of Drift, and often nothing but scattered bowlders and scratches and furrows on the rock surfaces.

Glacial scratches are abundant on the surfaces of the

harder sandstone outcrops, especially in Mead, Fairfield, Greenwood, East Fallowfield, Randolph, Wayne, East Fairfield, Union and South Shenango townships. The scratched rock almost always belongs to the Sharon Conglomerate. As this rock has been eroded from the highlands north of Crawford county, and lower and softer measures take its place, no scratches have been seen in Erie county, although they may exist beneath the soil.

Erratics are abundant, and some may be found 10′ in diameter; but they are not anything like so numerous as they are in Mercer, Lawrence and Beaver counties further south, where they form groups or colonies which almost conceal the soil.

I see nothing in Erie and Crawford counties to change the views expressed in my report QQQ on Mercer county. The erratics were not brought by icebergs, but by glacial ice; and they naturally increase in number southward in the direction of the motion of the great Beaver valley glacier, on the principle of a terminal moraine. Every alternate advance and retreat of the glacier would add to their numbers; while the finally retreating ice would merely drop here and there those which were on their way.

*Buried Valleys.**

Scarcely a stream of any considerable size in Erie or in Crawford county flows over a rock bed, except those which cut deep ravines on the Lake Erie slope, as already sufficiently described in Chapter 1. The present water-courses meander along the upper surfaces of Drift deposits which fill up the ancient valleys to various heights above the old rock beds, even in some places where no living stream now flows.

The 285′ drive-pipe of the Smith well, so-called, sunk in the valley of French creek, about 4½ miles below Mead-

* On page 18 of Report QQQ, Mercer county, I am made to say that the buried valleys of the Chenango and Pymatuning are 700′ deep. The reader will be kind enough to correct this to 100′, as I wrote it.

ville (see Part II below),* serves to indicate the depth of the old valley floor. The hole was commenced on the plain, 20′ above French creek, or 1055′ above tide (*482′ above Lake Erie*). The bottom of the pipe was therefore at 770′ (*197′ above Lake Erie*).

Bed-rocks are frequently seen along French creek, at Union, Venango, Mill village, LeBœuf and elsewhere; but the flood plain being two miles wide, there is ample space for a buried valley between the two wall slopes. None has been reported, but oil borings are not numerous.

The buried valley of Conneaut lake has been already described. Its side-hills are 300′ above the present plain. The depth of the old rock floor is unknown.

No rocks in place are seen along the Cussewago from Meadville up to near its head. The stream winds along between low banks of sand and glacial débris which probably fill an ancient and now deeply buried valley-bed.

Similar appearances indicate buried valleys along the Le Bœuf and Conneautee creeks; along Muddy, Woodcock, Sugar and Little Sugar creeks, as described in Chapter 1.

On Sugar creek west branch, not far above Sugar lake, Mr. Allen's drive pipe measured 80′.

On Sugar creek north branch, near the south line of Troy, 5′ above the creek and 1260′ above tide, Mr. Jno. Armstrong's drive-pipe measured 130′.

On Oil creek, 6′ above the creek, and 1240′ above tide, a drive-pipe on the Reed estate just above Hydetown, was abandoned after going through Drift 190′.

On the Preston farm below Tryonville, 10′ above and near the creek, the drive-pipe reached bed-rock at 200′.

Just west of this, Mr. Gray's pipe was reported to touch bottom at 160,′ but no further boring was done.

* I found this depth given in the company's books at Meadville, and both members of the firm assured me that had all the joints not been driven, those not used would have been returned. The pounding down of the string of joints became so difficult at last as to advance but a few feet per week. In passing the numerous quicksand layers the drive pipe seemed to rebound under the blows of the hammer as much as to descend, and in one of these the work was abandoned.

Just below the Tryonville bridge, 10′ above water, a drive-pipe reached rock at 160′.

On the opposite side of the creek, near the old hotel, there is another drive-pipe of 160′.

On Oil creek east branch, about a mile above Centreville, 10′ above the creek and 60 rods east of it, two of Mr. Kinney's wells had drive-pipes of 90′ and 100′.

Half a mile above Centreville, 15′ above the creek (1260′) a well was abandoned because no bed rock was found at 100.′

The buried valley of Conneaut creek is the only one over which now flows water to Lake Erie. It is evidently a continuation of that of Conneaut lake, where Mr. Scofield found 187′ of Drift as already described. It continues northward to the great bend, and *possibly* six miles further to the shore of Lake Erie; but the topographical aspect of the locality is not favorable to this supposition. The Conneaut, turning aside at the bend cuts westward an open ravine through the native rocks.

Raccoon and Crooked creeks carry very little water and flow over gravel, only cutting through it near their mouths; the rest of the Lake Erie streams have rockbeds their whole course.

The most remarkable of these buried valleys are those through which two streams now flow in opposite directions from a common divide, scarcely more elevated than other parts of the flood plain. These have already been mentioned cursorily; a few more words will complete the description of two fine examples of this phenomenon in Mead township, Crawford county.

Mill creek (south branch) and *Mud run* have their heads together in a common wide and deep level valley, Mill creek flowing north to Meadville and Mud run south into Little Sugar creek. A swamp feeds both. The two valley walls slope gradually upwards to a height of 350′. There must be an older and deeper valley bed buried beneath this swamp and these two streams; and along this ancient rockbed a single stream must have flowed in one or the other direction.

Little Sugar creek (east branch) flows southward past Mead's Corners in a similar Drift-filled ancient valley, out from an imperceptible divide in northern Mead township, from which another stream flows north into Woodcock creek. The hill walls are here 200′ high.

Woodcock creek and *Sugar creek*, west branch, head together at Guy's mills (as already described) on the flat floor of a through-cut valley bounded by hills 200′ high.

Muddy creek, south fork, and *Sugar creek*, north branch, head together at Townville, in a through-cut valley, the walls of which rise very high. A ridge of Drift 40′ high crosses the valley floor here and separates the streams.

French creek (south branch) and *Oil creek* head together, half way between Corry and Spartansburg, in a very remarkable through-cut valley of the same kind, by following which the P. C. & B. RR. gets through the high divide.

The hill tops are 1850′ above tide.

The railway summit grade is 1646′.

Mr. Crossman's oil well, half a mile from the summit, at the county line, and in the middle of the valley, went down 150′ through Drift to the ancient rock bed at 1425′.

The total rock-cut is therefore 425′± deep.

There is no water now at the railway summit; a rill feeds French creek northwards, and another feeds Oil creek southwards.

The ice grooved country about Corry, 5 miles distant, northward, stands at 1425′ to 1440′.

Hare's creek, in Wayne township, Erie county, flows south and east into the Brokenstraw, from a swamp in the floor of another such ancient through-cut valley now half filled up with Drift; and from the same swamp flows northward a stream into the north branch of French creek. The hill walls at the New York State line rise 150′ above the valley floor.

LeBœuf creek and *Elk creek* head in Tamarack swamp in such a cut through the Great Divide, as already mentioned.

Conneaut lake and swamp, and *Pymatuning swamp*, both already described, repeat, on a much larger scale, this

phenomenon which has attracted the attention and has excited the curiosity of intelligent inhabitants of Erie and Crawford counties, who demand some geological explanation.

This must take one or both of two shapes: Either 1, these *ancient buried valleys* were excavated by ancient rivers flowing from one to three and even four hundred feet beneath the present valley Drift floors; or, 2, they have been excavated by the great southward moving Canadian Ice sheet, which as it retreated filled them up again with the trash which it carried; or 3, they were first excavated by preglacial rivers, then deepened and widened more or less, and grooved and scratched and polished by the ice, and filled with its moraine matter to the present levels.

Some geologists assign a higher and others a lower degree of eroding power to moving or glacial ice. Even in the Alps, where the whole process of cutting and carrying and dropping is seen going on—where the production of medial, lateral and terminal *moraines* can be watched—where the thickness, rate of motion, and change of constitution from snow to *nevé*, from *neré* to blue banded ice have been measered and calculated—where *dêbacles* or avalanches of ice, rocks, mud and water periodically occur, and spread fresh layers of Drift over cultivated valley floors, constructing swamps and lakes behind ridges, and then filling them up again—where, in fact, geologists have been trying for many years to define accurately the erosive force and rate of action of glaciers—they have not yet succeeded in agreeing about either of these. It is impossible therefore to speak with any confidence about them in such a region as Erie and Crawford counties from the surface of which the Northern Ice disappeared many ages ago.

Mr. John F. Carll has stated his view of the subject and given a large amount of data to support it in his Report I.I.I. in which he assigns the buried water-ways to ancient rivers, draining northwestern Pennsylvania towards Lake Erie.

My conviction is that Erie and Crawford counties could not have been drained in that direction; and therefore that

the buried water-ways must have owed their origin to the plowing power of Ice.

Terraces.

The Beaver river terraces do not reach Erie and Crawford counties. The streams usually meander between banks 15′ or 20′ high, in a broad and often nearly level flood plain, with nothing to indicate successive stages of erosion, and edging sharply against the hill slopes; and these also show no terraces.*

Along the Lake Erie front there are many fragmentary and obscure remains of old terraces, marking ancient higher levels of the lake surface.

From the top of the bluff east of the Ohio Line the land slopes upward regularly and very gently, covered with a continuous beach-sand and shore-shingle deposit to 800′ above tide,† proving that the level of the lake used to be at least (about) 225′ higher than at present.

Going eastward along the shore the Bluff gets continually higher, and often rises abruptly to 80′, 100′, or even 125′, and from its top the land has a gentle slope to the foot hills at from 400′ to 450′ (950′–1000′ A. T.)

East of Erie this sloping plain has been left more in its original condition, because the streams are small and cut straight down through it to the lake. A spectator placed near Belle Valley and looking eastward sees it as a continuous flat (1000′ A. T.), from which (south) rises an irregular escarpment of higher land on which I could find no shore deposits; but on the flat itself beach sand, &c. has been left in many places.

In Harbor Creek and western Northeast townships there is the nearest approach to a series of terraces, thus:

1150′, a wide level, 3 miles back from the lake; *destitute of beach deposits* (577′ above the lake).

Abrupt descent northward down to—

* The Ohio and Beaver valleys received at least 125′ and possibly 300′ of Champlain clay deposits; and their reëxcavation left terraces. The Crawford and Erie valleys lie from 400′ to 600′ higher above tide and escaped both processes.

† Pittsburgh, *low water mark*, 700′. See Report N, p. 211.

1070′, the remnants of a terrace, *covered with beach sand and shingle.* The waters of Lake Erie, therefore, must have stood above their present level about 500′.

A rapid descent over a rough escarpment *wholly destitute of beach deposits*, down to—

875′, the southern upper edge of a very broad sloping plain, *covered with beach sand*, &c.*

795′. At the northern lower edge of this plain is a *genuine terrace* (the only one I could find along the whole lake front) on the township line a short distance north of the L. S. & Mich. RR. It is a sharp escarpment of *beach sand*, 40′ high, which extends for a long distance parallel to the shore.

765′, foot of terrace, covered with yellowish white clay, manufactured into bricks.†

765′ to 740′, a plain a mile wide to—

740′ top of Bluff, descending steeply to—

573′, water's edge of Lake Erie.

It is, of course, impossible to assert the former non-existence of other benches or terraces at other elevations, on this great slope, from 1050′ to 573′, because such may have existed and been obliterated. But it can be asserted that the high level of the lake waters existed after the Ice age, because *the sand and gravel beach at 875′ rests on Northern Drift*, and must therefore have been formed after the retreat of the ice.

Lake basins.

§ 10. All the small lakes, without exception, lie in hollows in the surface of the Drift, filling the valleys.‡ All of them are shallow. The greatest *reported* depth, 100′, is

* The top of the highest (4th) terrace of the Ohio and Beaver rivers at New Brighton is given (doubtfully) at 885′ in Report Q, Preface, xxvii, and p. 12.

† At New Brighton the railroad runs along the top of the Second Terrace, at about 750′. This not the brick clay terrace of the Ohio; the brick clay there is in the Fourth Terrace, at 885′. Q, p. 13.

‡ Lakes, ponds, and swamps abound in all those regions of Europe and America which are covered with glacial Drift. In fact the southern limit of the Ice Deposits can be recognized on such maps as represent the lakes and ponds of a country.

in one place in Conneaut lake. Their surface levels above tide, and above Lake Erie, are as follows:

	Ocean.	Lake.
Conneaut lake* (Roberts),	1070′	497′
Sugar lake (White; barometer),	1280′	707′
Oil Creek lake (Carll),	1389′	816′
Conneautee lake (Carll),	1196′	623′
LeBœuf lake (White; bar.),	1180′	607′
Lake Pleasant (White; bar.),	1325′	752′
Chautauqua lake, N. Y. (Carll),	1299′	726′
	1305′	732′
Cassadaga lake, N. Y. (Carll),	1305′	732′
Lake Erie (Gardner),	573′	0′

Peat and Marl Beds.

In many of the bogs of this district an earthy variety of peat is now forming, and in some it is tolerably pure.

At the marl works, above Harmonsburg, on the land of Mr. Almon Whiting, 2′ to 3′ of earthy peat covers the marl, and is used in burning, or rather assisting to burn the latter.

This has been formed from the roots and stems of several species of *Cyperus*, *Carex*, and others of the same family, which are still contributing to its growth, as can readily be seen where the formation is cut through.

A small stream of water oozes through the bog, however, and in seasons of floods carries down so much sediment that the so-called "peat" is little better than a richly carbonaceous earth, which, when burned with the marl, contributes a large proportion of insoluble substance of no benefit to the soil, and very little that is of any importance whatever.

Under the peat at Mr. Whiting's comes a great bed of *fresh-water shell marl*, formed from the partial decay of fluviatile shells, principally univalve. The marl is mined to a depth of 6′ to 8′, and Mr. Whiting bored down through the deposit to a depth of 22′, and still did not pierce its bottom.

The peat bog in which this marl occurs, has now an elevation of 25′ above the present level of Conneaut lake, as

* Col. W. M. Roberts. 1840. Then (1082) behind its artificial embankments, now in ruins.

near as I could determine it by barometer, and there can be no doubt that this lake, now 1½ miles distant, once spread its waters over the marl beds, since there are about 60 acres of the marl on the land of Mr. Whiting, and a large amount on the land of Mr. Brown, adjoining, where, according to report, a bed of peat was found beneath the marl.

A collection of the more common shells found in the marl deposit was made and forwarded to Mr. George W. Tryon, Jr., of the Phil. Academy of Science, who kindly identified them and sent the subjoined statement:

"The fluviatile fossil shells from the vicinity of Conneaut lake are all representatives of existing species, which ought to be found in the lake, and *are* found throughout the waters of the State. I do not find any of the extinct forms which are so abundant at White Pond, Warren Co., N. J., a locality which, so far, has furnished several species peculiar to it. The following are the names of the species:"

Planorbis bicarinatus, Say.
Planorbis trivolvis, Say
Planorbis campanulatus, Say.
Planorbis parvus, Say.
Physa heterostropha, Say.
Limnaea humilis, Say.
Amnicola limosa, Say.
Sphoerinum striatinum, Lam.

The mode of accumulation of the marl beds is evident. There are found running through the marl from the top as far down as it has been explored (and presumably to the bottom) the stems of the ordinary Pond-weed, or a species very closely allied to it. These water plants grew and flourished in the old lake bottom, and on them countless millions of river molluscs fed and found a home just as we now see them in the shallower parts of the lake where the water grass grows. Their cast-off shells, &c. accumulated and were ground together by the waves into a bed of marl.

As the water grass or pond weed will not grow in water of a greater depth than five or six feet—I have myself seen none growing in water deeper than four feet—and as the

bed of marl is at least twenty-two feet thick,* the level of the lake water surface must have gradually risen during the formation of the marl; and at the same rate; so as to allow the grass always to be growing in a proper depth of water.

A specimen of the *raw marl*, obtained from Mr. Whiting and analyzed by Mr. McCreath was composed as follows:

Lime,	49.129
Magnesia,	.839
Iron bisulphide,	.429
Oxide of iron,	.170
Alumina,	.020
Potash and soda,	.116
Sulphuric acid,	.222
Phosphoric acid,	.023
Carbonic acid,	39.356
Water,	2.190
Organic matter,	6.510
Silica,	1.052
Total,	100.056

This marl is a good *lime manure*, and that is all; for the phosphoric acid and alkalies are in very small quantities.

Marl beds are reported to exist in the Conneaut lake creek marsh; and this makes the former extension of Conneaut lake in that direction certain.

* This is the greatest depth reached by exploration, measuring from the old bottom of the lake downwards. The marl *may* be much thicker.

CHAPTER IV.

Order of the Formations.

The *Productive Coal Measures* have been eroded from Crawford and Erie counties. The universal gentle south dip brings them into the hill tops of Mercer, but shoots them into the air over Crawford county. How far they once extended northwards is unknown.

The *Pottsville Conglomerate*, No. XII, has also been largely swept away. Its lower beds (Sharon Conglomerate) form the lower highlands of southern Crawford ; its middle beds (Connoquenessing Sandstones) the higher highland ; and its topmost beds (Homewood Sandstone) remain capping two of the highest elevations. The areas thus occupied by the formation are represented on the geological map by a dark grey color surrounded by a rim of red (Shenango Shale possibly *Mauch Chunk*, No. XI ?)

The *Pocono* and *Catskill* formations, Nos. X and XI, of Middle and Eastern Pennsylvania, are apparently represented by *Shenango*, *Meadville*, *Sharpsville*, *Orangeville*, *Corry* and *Cussewago beds* (in descending order), and perhaps also by the *Venango Oil Sand Group.*

All except the last (*Oil Sand*) *Group* are represented, without distinction, by the broad belt of light gray which covers most parts of Crawford county, the high divide south of French creek, and several areas of high land north of it.

The Venango (*Oil Sand*) *Group* forms by its northern outcrops the high divide of Erie county overlooking the Lake; and its whole southern slope, including the broad lands of French creek and its branches, and the valley walls as far down as Meadville ; as well as the lands bordering the upper waters of Conneaut creek. To this group has been assigned on the map a separate color for the sake of distinction ; and the color selected is that assigned to the *Catskill formation* on all the other geological maps published by the Survey , although it has not been proved that the Ve-

nango Oil Sand Group is in any part of Catskill age; and part is probably of Chemung age. But the absolute unity of the group has been amply demonstrated, and is a fact of such immense economical importance, that no option was allowed as to giving the group a single and separate section of the color scale.

The Chemung formation (uppermost member of No. VIII) outcrops along the northern slope of the great divide facing Lake Erie; and its upper beds occupy the broad flat valleys of French creek north branch, and LeBœuf creek, as far down as their junction. Its color on the map is a light shade of Vandyke brown.

The Girard shale beds, exposed in the cliffs of the ravines descending to the lake, are represented on the map by a band of darker brown.

The Portage formation, exposed along the lake shore, and in the ravines, is represented on the map by a still darker tint of brown. The top of this formation appears above water-level about 2 miles east of the Ohio State line, and gradually rises eastward until 475 feet of Portage beds are seen at the New York State line. The whole thickness of the formation in New York is about 1400′. About 1200′ of it are therefore under ground at Erie.

The Genesee, *Hamilton*, *Marcellus*, *Upper Helderburg*, and *Oriskany* formations lie still deeper;* and underneath these lie the SILURIAN formations, which rise to the surface in Canada and Middle New York, viz: *The Lower Helderberg*, *Niagara*, *Onondaga*, *Clinton*, *Medina*, *and Oneida;* beneath which lie the CAMBRIAN or Siluro-cambrian formations, viz: *The Hudson river*, *Utica*, *Trenton*, *Calciferous*, *and Potsdam*, which last lies upon the HURONIAN system.

A vertical section of the formations, with their subdivisions, names, characters, thicknesses, and coloration will be found on the side of the geological map accompanying this report.

* From Chemung to Lower Helderburg is No. VIII. The Oriskany is No. VII. All including Catskill above and Oriskany below (*i. e.*, IX, VIII, and VII) are commonly known as the DEVONIAN system.

Chapter V.

Dip of the Rocks.

(With a discussion of the data by J. P. Lesley.)

The only instance of dip towards the north which I have found occurs in the center of Erie county, two miles south of McKean's Corners. Here, for a short distance only, a very slight northward fall of the rocks towards the lake can be detected.

Everywhere, throughout both counties, the strata appears to be horizontal, but in reality possess an exceedingly gentle dip southward, away from the lake and towards the Allegheny and Ohio rivers.

In obedience to this southward slope, higher and higher formations make their appearance in belts across the country, as shown upon the map. And this continues to be the case all the way south to the Ohio river, and in fact to West Virginia.

No anticlinals and synclinals, such as make so marked a feature of almost all other geological districts of western Pennsylvania, and play so important a rôle in the distribution of the surface outcrops, exist here. If there be any anticlinal and synclinal undulations at all in Erie and Crawford counties they are so exceedingly flat that nothing short of an expensive system of measured borings, connected by instrumental surveys, would suffice to reveal their presence, measure their force, and determine their direction; which, by the way, should be from northeast to southwest, at some angle approximately parallel to the anticlinal rolls of Clarion, Butler, and Beaver counties.

The force of the general dip southwards, between Lake Erie and Franklin in Venango county, was estimated during the First Geological Survey of the State, forty-three years ago, by James T. Hodge, at *one seventh of one degree*, or about 14′ per mile.

The following tables embody the data, obtained by my recent survey, for recalculating the rate of the general dip on lines running approximately *due south.*

A. Along the meridian of Corry

Shenango Sandstone (base.)

	Miles.	*A. T.*	*Rate.*
One mile south of Corry,*		1950′	
East of Oil City,	36	1215′	25′

B. Along the Meridian of Cambridge.

Shenango Sandstone (base.)

Reynold's quarry, Summit T. Erie Co.,†		1985′	
Shreck's, at Crawford-Mercer line,	32	1315′	21′

C. Along the Meridian of Conneaut lake.

Shenango Sandstone (base.)

Three miles east of Cranesville,‡		1750′	
Three miles west of Atlantic Station,	30	1235′	17′

D. From Erie to the Ohio river

At Erie.—Lake surface,	573′		
Portage rocks visible,	220′		
Girard and Chemung,	550′		
Third Oil S. seven miles S. of Erie,		1343′	
Beaver Falls Economy well mouth,	735		
Third Oil Sand in well, down,	1090′		
		—355′	
Fall of *Third Oil Sand,*		1698′	
Distance in miles,		85	
Rate of fall, as thus calculated, §			*20′*

*The elevation is here calculated in the air at 210′ above the *Corry Sandstone* 1740′ A. T. (above tide.)

† Elevation calculated in the air by adding 675′ average interval between Third Oil Sand (here 1310′) and Shenango Sandstone.

‡ Elevation here calculated by adding 675′; Third Oil Sand being 1075′.

§ Or by using the known fall of the Ferriferous Limestone from Beaver falls to Rochester 137′, the total fall of 137′+1698′=1835′ in 89 miles, would be at the rate of 20½′ per mile.

E. From Lake Erie to the Ohio river.

Ohio low water and Ferriferous Limestone; . . Rochester,* at mouth of Beaver river;	666′	
Down to Shenango SS. 400′, ...	266′	
Down to base of Third Oil Sand, 675′, . . .	—409′	
Down to *top of Portage flags*, 550′, ...	—999′	
Top of Portage flags at Erie above Lake, 220′,	+793′	
Fall of *top of Portage* from Erie to Rochester, ...		1792′
Distance, South 5° West, in miles, ...		96
Rate of fall, as thus calculated,†		*18 .65′*

As it is impossible for the eye of a field geologist to detect a dip of even much greater value than those arrived at by the above calculations—as broad intervals of no exposures occur, and as changes of deposit within unknown limits are also frequent, or rather universal—it is quite possible many slight variations in the rate of dip, and even exceedingly delicate undulations, may exist, unimportant in their details but yet exerting a decided influence on the calculations of rock intervals, and even on the topography.

If such undulations exist we should expect their axis-lines to run east and west, or rather at some angle of the compass between south and west;‡ and to one of these may possibly be due the topography of the South Branch of French creek.

Comparing Table A above with the following Table F it will be apparent that there must exist some such variations:

F. On the meridian of Franklin.

Third Oil Sand.

	A. T.	
Erie Divide, N. Y. State line, ...	1600′±	
Franklin, Venango county,§	421′	
Fall, ...		1180 ±
Distance in miles, ...		56′
Rate of dip southward per mile, ...		21′

*Same as at Beaver, 666′. N, p. 211.

†A slight thickening of the formations southwards is not regarded. The interval thicknesses were obtained along the whole line, and grouped.

‡Mr. Carll has found reasons for suspecting the existence of such undulations, running east and west in Warren county.

§ Report I.I.I. Carll, 1879, Plate VI, Fig. 23.

According to the rate given along very nearly the same meridian in Table A, viz: 25′ for the 36 miles from Corry to Oil City, the Third Oil Sand should rise in the 56 miles north of Franklin 1400′, and stand at (1400′+421′) 1821′ instead of 1600′ A. T. overlooking the lake. The loss of 221′ can only be accounted for by supposing something equivalent to *a belt of horizontality* somewhere between Franklin and Lake Erie *nine (9) miles wide*, which would more than cover the South Branch French creek topography. Or, by diminishing the width of this belt to 4 or 5 miles we are entirely at liberty to suppose a narrow belt of gentle north dip, which would make the South Branch actually drain along a trough.

The following tables show the slope of the stratification from east to west:

G. Along the parallel of Wattsburg.

Third Oil Sand (base.)

	Miles.	*A. T.*	*Per mile:*
At Wattsburg, N. Br. French creek,		1375′	
Near McKean's Corners,	16	1200′	11′

H. Along the Erie-Crawford Co. line.

Third Oil Sand..

N. of Mill Pond, Oil creek,		1175′	
N. of Spring P. O.,	36	925′	7′

J. Along the parallel of Meadville.

Shenango Sandstone.

a. ½ mile below Tidioute, Warren co.,		1600′	
b. 5 miles N. of Titusville,	11	1545′	5′
c. Townville,	12	1510′	3′
d. 1½ miles N. of Meadville,	13	1470′	3′
e. Ohio State line,*	20	1375′	4.75′
a to d,	36	(Fall 130′)	3.6′
a to e,	57	(Fall 225?)	3.8′?

K. Along the parallel of Franklin.

Shenango Sandstone (base.)

Franklin, Venango co.,		1095′	
Shenango village, Mercer co.,	30	1090′	0.2′

*Here the elevation A. T. is calculated in the air from the next outcrop.

The rate of the dip along east and west lines is therefore not constant over the region, but diminishes southward, from 11′ per mile to almost nothing. The four parallels of latitude to which the table attach are distant from each other respectively 10, 14, and 18 miles.

As there are two pairs of observations, one in the Third Oil Sand, and the other in the Shenango Sandstone, 675′ above it; and as both pairs obey the same law, it ought to govern all four, whether the two sands keep a constant distance of 675′ apart or not.*

But this conclusion does not seem supported by the two following tables of elevations observed along two parallel lines 30 miles apart, both trending S. 65° W.; one along the Lake Erie shore; the other from Garland, in Warren county, to Jamestown, in the southwest corner of Crawford.

L. Along the Lake Shore, S. 65° W.

Portage flags (top).

	A. T.		
New York State line, 475′ above the lake,	1048′		
Near the Ohio State line—lake level,	573′		
Fall of the top layers of the Portage,		475′	
Distance in miles,		40′	
Rate of fall S. 65° W. per mile,			12′

M. From Garland to Jamestown, S. 65° W.

Sharon Conglomerate.

	A. T.		
Garland, 6 m. E. of Crawford-Warren line,†	1833′		
Jamestown-Adamsvillehill,‡	1250′±		
Fall of Sharon Conglomerate,		583′	
Distance in miles,		54′	
Rate of fall S. 65° W. per mile,			11′

* These results agree with others obtained by a similar comparison of elevations at the outcrops of other rocks in the series, especially at the outcrops of the very persistent *Meadville Lower Limestone*, the exposures of which, however, are less numerous than those of the great sandrocks, and, therefore, the lines of comparison are shorter.

† Report I., Carll, p. 38.

‡ Report Q³, White, pp. 198, 199.

Considering the length and parallelism of these lines, the agreement of their average rates of fall (westward) is very striking and important; and all the more so, seeing that the Sharon Conglomerate overlies the Portage flags by about 1250′.

As undulations from the south northward have been shown to be probable, so it is possible that delicate undulations from the east westward may exist. But as the general dip towards the south and the general dip towards the west must be satisfied by *one resultant general dip towards the Southwest*, so a set of undulations north and south and a set of undulations east and west may resolve themselves into one set of undulations southeast and northwest normal in the Appalachian flexures. But this is not necessary. In all parts of the State a *dimple structure* has been demonstrated, the main system of flexures being crossed by a subordinate system transverse to it, neither of them being symmetrical, although obeying a general law.

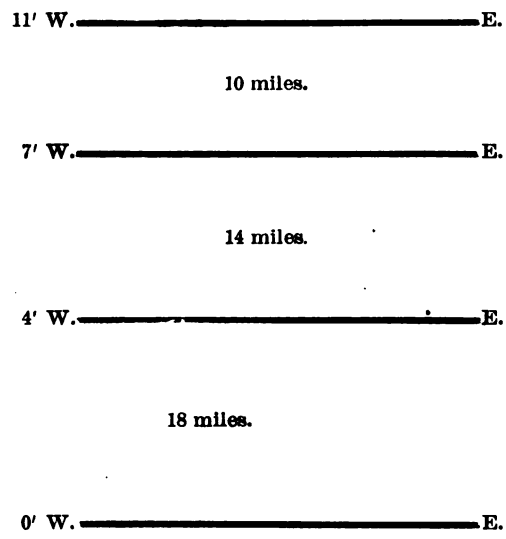
This *dimple structure* is finely shown by the example of the Somerset county coal basin map published in Report HHH, Platt, 1877; in the patches of Coal Measures on the Lycoming and Sullivan county maps, in Report GG, Platt, 1880; on the maps of McKean, Clinton, Potter, Tioga and Bradford counties in Reports R, Ashburner, 1880, G, Sherwood, 1878, G^3, Platt, 1880, and G^4, Chance, 1880. And it is now known to be illustrated on an unexpectedly grand scale in the Anthracite coal basins, as shown in the map and model of the Mahanoy and Shenandoah district lately constructed by Mr. Ashburner.

The upper northeast end of a synclinal trough in the Venango Oil Sand Group is shown by contour lines in the four small *underground maps* of the vicinity of Pleasantville in Venango county, given on pages 19 and 21 of Report I, Carll, 1875.

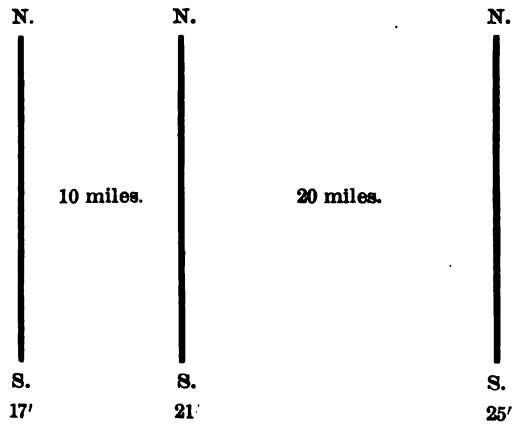
These maps instruct us concerning the irregularities which must necessarily exist in general dip over a large region like that of Erie and Crawford counties, and how the *resultant dip* shifts often 10°, 20°, or even 50° in a few miles.

One very remarkable result from the above table requires a more particular notice.

The series of east and west lines give diminishing rates of *west dip*, going south; thus:

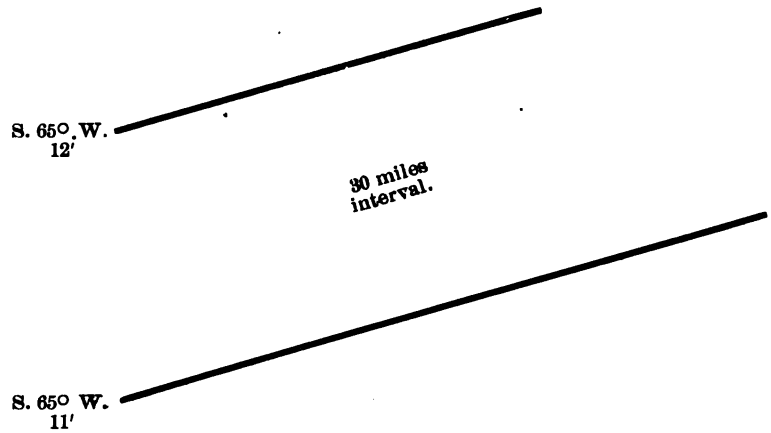


The series of north and south lines give diminishing rates of *south dip* going west; thus.



These of course agree in showing a *warped structure*, as if the whole area crossed by these lines had at first been horizontal, and then had been tilted by the elevation of its *northeast corner*; but that in the tilting the *northwest corner* had sagged downwards, or not wholly shared in the regular general tilt. And the area crossed by these lines is very extensive, being 42 miles long by 30 miles broad, allowing ample space for many slight undulations, dimples, or other undiscoverable slight irregularities.

But, on the other hand, *no such warped structure* is shown by the two diagonal lines, S. 65° W. thus:



These seem to show that the whole region has been tilted *regularly* and *evenly* at its *northeast corner*, without any warping or sagging—so far as it concerns the *geological horizon of the top of the Portage Flags*—and so far as it concerns the *geological horizon of the Sharon Conglomerate*, 1250′ higher in the series.

Is it possible then that the *warped structure* is confined to some one or more *intermediate geological horizons*—that of the Third Oil Sand for example?

From a mechanical point of view this would seem to be impossible.

But from a sedimentary point of view it is quite possible.

There is then *a suggestion of non-comformability* in the

above tables—supposing, of course, that their data be reliable.

In other words, it looks as if the sediments *overlying the Portage* were *thinner*—and the sediments *underlying the Sharon Conglomerate* were *thicker*—in the northwestern region of the general area, than in the eastern and southern regions.

A gradual thinning of the Sub-Carboniferous and Devonian measures from Middle Pennsylvania into Ohio was demonstrated by the First Geological Survey, and has been amply discussed and illustrated in the Reports of 1875-1880, particularly in a special report in G^4, Chance, 1880. It appeared also from the reports of the New York State Survey published in 1844, and in the various recent reports of the Ohio State survey; and it must be an important factor in all future calculations of dip and thickness where the stratification approaches the horizontal, as in the Lake Erie region.

The normal directions of dip in Western Pennsylvania are northwest and southeast wherever the undulations are prominent, with their axes striking N. E.—S. W.

But beyond the last noteworthy anticlinal crossing Butler, Clarion, Forest and McKean counties the whole country to the northwest of it is practically destitute of anticlinals and synclinals, and exhibits not N. W.—S. E. dips but a general *southwest dip* into middle-eastern Ohio.

To get *one single direction* for this general dip is impossible, as it varies; and its variations are due to a *dimple structure upon a general southwest slope.*

In Erie county we might assume the direction at S. 80° W. by comparing Table G with Table L. For we have a fall-rate of 11′, S.65°W. in one, and of 12′, S.90°W. in the other, and the resultant would be something 12′ plus, about S.80′W.

But the one is along the top of the Portage and the other is along the horizon of the Third Oil Sand, 550′ higher in the series. Any thinning of this interval westward would materially affect the direction of the resultant.

In Crawford county we may compare with far more suc-

cess tables H and M; for their lines meet eastward in Warren county; and they both relate to the *Sharon Conglomerate.*

In Table H we have a rate of 7′, S.90°W.

In Table M we have a rate of 11′, S.65°W.

There is no question here of a resultant between these two directions. There must be a still greater rate at any angle *less than 65°, S. W.*

In table A we have a rate of 25′ South, (dependent however on a calculation of thickness) but relating to the Shenango Sandstone which underlies the Sharon Conglomerate only a few yards.

In Table F we have a rate of 21′ South, along the line of Table A projected to Lake Erie.

It is possible then that we have south of Corry a *maximum rate of 25′ locally directed* southward.

It is also possible that there is *a greater rate than 25′* along a line *west of South.* But this cannot stand for a general southwest rate for the whole region.

Mr. Carll's rate and direction between Tidioute and Rouseville, 20.7 miles, taken on the upper surface of the Third Oil Sand in Venango county, is 21.7′, S.45°W.*

This agrees sufficiently well with the data obtained in Erie and Crawford counties, and may be accepted as the best general formula to be obtained in the premises.

And on the basis of a 21.7′, S.45°W. the 11′ and 12′ rates of fall along the Lake shore and the Crawford county long S.65°W. line come in just right.

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*See Report I, Carll, 1875, p. 18. The elevations are numerous; all of them instrumentally referred from oil well records to Tide level; and therefore as reliable data for the calculation as could be desired.

[NOTE, Dec. 22, 1880. I have just received from Prof. J. W. Spencer of Winsor, N. S., his *triangulated dip* of the top of the Niagara limestone from the west end of Lake Ontario S.20°W.—rate 25½′ to the mile.—J. P. L.]

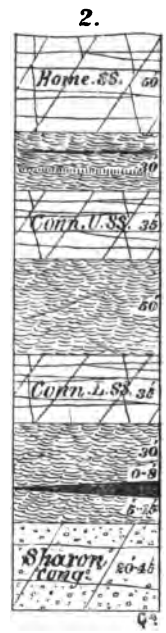
CHAPTER VI.

Pottsville Conglomerate, No. XII.

This great formation of Eastern and Middle Pennsylvania, Maryland and Virginia, is represented along the southern border of Crawford county, by four more or less massive, and sometimes pebbly sandstone deposits separated by softer shaly layers, which in the neighboring counties hold beds of coal, limestone and iron ore, as shown in the following generalized section, Fig. 2:

2.

HOMEWOOD SANDSTONE, ...		50′
Mercer group, ...		30
CONNOQUENESSING,	UPPER SANDSTONE,	35′
	Quakertown beds, .	50′
	LOWER SANDSTONE,	35′
SHARON,	*Upper iron shales*, ...	30′
	Coal, ...	0′ to 8′
	Lower shales, ...	5′ to 15′
	CONGLOMERATE, ...	20′ to 45′
Average total in Crawford county, . .		276′



Homewood Sandstone.

This deposit, which is of such importance in every part of the Bituminous and Anthracite coal fields of Pennsylvania, has been almost entirely eroded from the surface of the Lake Erie region, and the few fragments of it which re-

main along the southern edge of Crawford county, in the highest summits, are concealed beneath a covering of Northern Drift.

Where the Fairfield-Greenwood township line joins the county line, a coal boring on a small hill top went through 50′ of sandstone, probably the *Homewood.*

In Wayne township, south of Sugar lake, near the county line, a Drift-covered hill top, rising 325′ above the *Shenango sandstone*, ought to hold the *Homewood.*

Mercer Group.

The Mercer shales (60′ to 70′ thick in Lawrence and Mercer counties, with three or four coal beds, and two limestones), appear along the southern border of Crawford county only as sandy shales, everywhere concealed by the Drift; but a drill-hole near the southwest corner of Fairfield reported a few inches of coaly substance (no limestone) in 30′ of shales.

Connoquenessing Upper Sandstone.

This rock caps a number of high knobs.

On Culver and Dyce's knob, in the middle of Greenwood, 1400′ A. T., large masses of grayish-white pebbly sandstone lie 130′ above the *Sharon coal* opened in the flats below.

Jno. Shepard's knob, in E. Fallowfield, 1420′ A. T., is capped with massive white sandstone, 125′ above the *Sharon coal.*

Several hills in Fairfield towards French creek and Conneaut lake are capped by it.

Voison's quarry, on the south side of a high ridge in Randolph, shows 30′ of very hard, white, tolerably coarse-grained sandstone. Top of rock about 1550′ A. T.

McCartney's ledge, near Randolph P. O. The upper surface of the white, coarse sandstone is *scored with glacial furrows.* Top of rock 1650′ A. T. Dip for five miles to Voison's, south, 20′ per mile.

Powers' knob, 2 miles east and a little north of McCart-

ney's ledge, at the southern edge of Richmond, is capped with white sandstone; 30′ visible; top 1650′ A. T.*

Honey-comb rock.—In Troy and Steuben townships where the hills often rise above the horizon of this stratum, there are often found great numbers of small bowlders of a sandstone which is pitted with small cavities in such a manner as to give it a rude resemblance to honey-comb, or more accurately, to a hornet's nest. The small cavities seem to be filled with a ferruginous clayey material which readily crumbles and falls out when it is exposed by fracture and thus leaves the sandstone punctured with numerous small holes ¼″ to ⅜″ in diameter.

At Franklin in Venango county, away back in the hills somewhere, there is a quarry in a stratum that is marked in exactly the same manner. It is used for railroad ballast along the Allegheny valley, and it always presents this same peculiar appearance. I have never had the opportunity to go up to the quarry near Franklin, but it lies probably 200′–250′ above the *Shenango Sandstone* which is the lower quarry rock there, and from this fact I have thought it possible that the "pitted" sandstone at Franklin may be identical with the *Upper Connoquenessing;* but whatever the rock may be the blocks scattered over the eastern portion of this district have evidently come from the same bed; and the fact that they are found 20 miles and more away from Franklin shows that this peculiar structure must have been characteristic over a wide extent. The subject deserves further investigation at Franklin, and perhaps the stratum may be identified by this peculiar feature far to the eastward.

Quakertown Shales.

The Quakertown coal exists in the Voison Knob, S. W. corner of Randolph; since lumps of outcrop coal are found in the large spring under the quarried sandstone.

Elsewhere its outcrop is always concealed by sandstone fragments fallen from above.

* If this be the *Conn. Upper* SS., it ought to be higher than McCartney's. It is probably, therefore, the *Conn. Lower* SS. which would agree with the fact that the *Shenango SS.* is seen just west of it, only 200′ lower.

A coal bed opened in Pine Knoll, Wayne, and a coal bed opened south of Sugar Lake, which I at first identified with the *Quakertown coal* of Mercer county, 180′ above the Meadville Upper Limestone, I afterwards saw cause to identify with the *Sharon coal.*

The *Quakertown iron ore* of Mercer county has not been seen in Crawford.

Connoquenessing Lower Sandstone.

This rock is seen at several localities along the southern border and is nearly always a very hard, coarse, sometimes pebbly, often micaceous, grayish brown sandstone, with occasionally a tinge of buff.

On Miller's land, S. line of E. Fallowfield, it overlies the *Sharon coal* 15′, and is 40′ thick; disintegrating on exposure to the weather.

At McEntire's, further north, in E. Fallowfield, only 10′ of it remains (from 5′ to 10′ above the *Sharon coal*) broken into large and small fragments, perhaps by the passage of the Northern Ice.

At the top of Pine Knoll, west part of Wayne, it overlies a worked coal bed, and is crushed to fragments. It is here a very coarse, micaceous stone, readily disintegrating under the weather.

On Wentworth's and other farms south of Sugar lake, and on McDaniel's land at old Liberty Furnace, across the Venango county line, it is visible.

The Connoquenessing Lower Sandstone is sometimes itself divisible into two, separated by 20′ or 30′ of shale; its lower sandy mass then forming the roof of the *Sharon coal* bed.

Sharon Upper (Iron) Shales.

Owing to the very limited extent of the *Sharon coal* in this district, the usual *iron bearing shales*, so often seen above it in the Mahoning and Shenango valleys, are but seldom exposed, and have yielded *iron ore* only in two instances.

At Jas. M. Snodgrass's near Jamestown, in S. Shenango,

a 2′ solid *iron ore* bed, covered by 4′ blue shale, was stripped from the hill top, and sent to Greenville & Middlesex furnaces. The ore, lying in dish shaped depressions, frequently ran out.

A thin *coal bed* underlies the ore, and may represent a rider of the *Sharon coal*, as often happens in Mercer county. It lies 140′ above the base of the *Shenango Sandstone* in the hollow to the west.*

At McDaniel's on Sugar creek and the Venango county line, a rich *carbonate iron ore bed*, 1′ has been stripped and drifted into for Liberty furnace. The shales above it hold much *Kidney ore*, which was also mined. The *Sharon coal* lies 20′ under it.

This *iron ore* horizon might doubtless be found workable at other places along the southern edge of Crawford county, but I could hear of no explorations for it.

Sharon Coal.

This coal bed, so important in Mercer county, and across the State of Ohio, is thin and poor and appears only at intervals around the edges of the high isolated areas of Conglomerate, in Crawford county; but its *theoretical outcrop* is marked by a continuous dotted black line upon the map.

Except in a few isolated knobs which catch it in their summits further north, it is confined to the southern tier of townships in Crawford county; and as a workable bed it is almost confined to East Fallowfield, through the hills of which it spreads pretty generally and regularly.

At O. K. Miller's mine near the county line (where several hundred tons were taken out before bad drainage spoiled the workings) the bed varies from 3′ to a few inches, and in some directions to nothing. It is somewhat slaty, but a genuine "block coal" as in the Mahoning and Shenango valleys.

It lies in 25′ of shales; 15′ over it is seen the base of 40′ of *Conn. L. SS.*; 10′ under it is seen the top of the massive *Sharon Conglomerate*, here very pebbly.

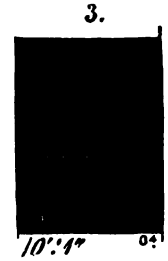
*I have never seen the *Sharon coal* itself, in the valley to the south, more than 100′ above the base of the Shenango sandstone; but on the edges of the old coal swamps the coal sometimes rises 40′ or 50′ in a few rods.

The McEntire settlement, two miles north of Miller's mine, furnished coal at an early day which was hauled to Meadville.

Jesse McEntire's coal was chiefly stripped; 20′ of shales and broken sandstone were sometimes thrown off, and then gangways were driven in the bed.

Jas. M. McEntire on the adjoining farm, described his coal bed to me thus, Fig. 3:

3.



Cannel, impure,	6′
Block coal,	4′
Total thickness,	10′

The upper bench was really a bituminous shale, although it could be burned, and very variable, often running down to nothing.

The lower bench also varies frequently between a maximum of 4′ and nothing.*

These McEntire mines were long ago exhausted.

Sharon coal bed floor, is here,	1330′ A. T.
Sharon conglomerate, 10′ lower,	1320′
Shenango sandstone, 75′ lower,	1255′

In Greenwood township several boring have reported the Sharon coal.

In Union township Huber & Clippel stripped a few tons from the steep slope of Dutch Hill, a high knob half a mile from French creek.

Sharon coal bed is here,	1440′ A. T.
Shenango SS. (base,) 95′ lower,	1345′
Meadville U. Limestone, 135′ lower,	1305′
French creek level, 385′ lower,	1055′

On the opposite slopes of French creek valley, two miles distant,† Byhm's shaft was sunk in 1878. Under 55′ Drift

* The identity of this coal with the *Sharon* is proved by the Conglomerate outcrop under it, and Jackson's quarry in the *Shenango sandstone*, full of ball ore and fish remains, 75′ below it, to the west.

† Near the north line of E. Fairfield, on Byhm's land; shaft sunk by Mr. Lewis of Pardoe.

it reached the coal bed where the glacial movement had crushed it into an unminable condition.

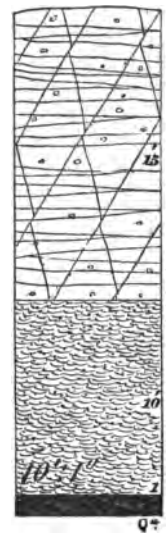
Sharon coal bed is here, ... 1445′ A. T.
Shenango sandstone (base) 125′ lower, ... 1320′
Meadville U. Limestone, 160′ lower, ... 1285′

In Mead township, three or four water wells report the coal bed, always under Drift and in a broken up condition:

In Wright's well, 2½ miles due east from Meadville, under 25′ of Drift, ... 1545′ A. T.
And in Boyles well, south of the last, ... 1515′

In Wayne township (southwest part) on the summit of Pine Knoll, where the coal has been worked on a small scale for a long time, many holes have been bored and the gangway has been carried far into the hill, and the outcrop thoroughly explored, but nothing has been made of the bed better than as represented in the following Peter Mentro section, Fig. 4:

4.



		A. T.
Conn. L. SS. coarse and pebbly,	15′	
Sharon shales, sandy,	10′	
Sharon coal bed,	1′	1475′
Meadville U. L. (1 m. SS.W.)		1300′

That this is the *Sharon* and not the *Quakertown coal* (as I at first thought, on account of the 175′ interval below it), is proved by the normal dip of (1475′—1445′) 30′ from here to Byhm's shaft, 6 miles west.

The interval (*Sharon coal* down to *Mead. U. L.*) has a regular thickening eastward, as shown thus:*

At McEntire settlement,			120
At Huber's, in Union,	10	miles,	135′
At Byhm's shaft,	2	"	160′
At Pine Knoll,	6	"	175′
Total increase in	18	"	55′

* A part of this increment is probably due to the thickening of the *Sharon Conglomerate* eastward in Warren, where it is the great *Garland Conglomerate* of Mr. Carll's reports, and into McKean, where it is the still more massive *Olean Conglomerate* of Mr. Ashburner's reports.

In the Wentworth oil boring (S. E. edge of Wayne) the *Sharon coal bed* was reported, at a depth of 55′, thus:—(A.)

	A.	B.
Coal, upper bench,	1′	10″
Cannel slate parting,	5′	4′ 0″
Coal, lower bench,	2′	1′ 6″

I tested the accuracy of the driller's report by a section, Fig. 5 (B), at an old Liberty Furnace opening, on a branch of Deckard's run, a mile distant, just over the Venango county line. Here the slaty parting could be burned.* Both top and bottom benches looked like *block coal*, free from sulphur.

Sharon coal, here, ... 1460′ A.T.
Meadville Upper L., 180′ lower, ... 1280′

showing a further slight increase of the interval in an eastward direction.

In Troy and Steuben townships numerous highlands rise high enough to catch the Sharon coal, but it has not been found, nor indeed much looked after.

Sharon Lower Shales.

Fireclay underlies the *Sharon coal bed*, and rests on shales, which sometimes graduate downward into the *Sharon Conglomerate* series. The interval between the bottom of the coal and the top of the solid sandstone varies from 5′ to 15′.

Sharon Conglomerate.

This wide spread deposit of sand and pebbles of quartz, has been surveyed throughout the whole extent of the western and northern counties of Pennsylvania from the Ohio river to Potter and Tioga counties, and is the accepted representative of the whole or of the lower part of the OHIO CONGLOMERATE.

In Warren and Venango counties it is known under the name of GARLAND CONGLOMERATE.

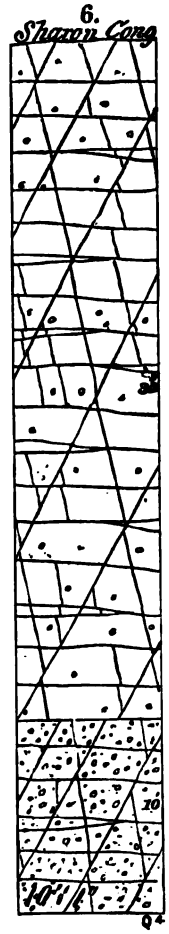
* I found in this slate a species of *Lingula* not distinguishable from *L. Newberryii*, Hall; found in the *Cuyahoga shale* formation of Ohio.

In McKean, Forest, Elk, Cameron, Clinton, and Potter counties it is known as the OLEAN CONGLOMERATE.

In the Clarion, Butler, Mercer, Lawrence, and Beaver reports it is called the SHARON CONGLOMERATE.

In the nomenclature of the Oil drillers it is the SECOND MOUNTAIN SAND.*

In Crawford county it is exhibited in a remarkably satisfactory and complete manner, by the Meadville quarries, in the College Hill, where it is plainly divisible into an upper and a lower member, as shown by the following section, Fig. 6:



Here building stone layers, with an occasional pebble, occupy the upper 35′; and the lower 10′ is a conglomerated mass of quartz pebbles.

This subdivision is by no means a universal feature of the deposit, but recurs in so many places that its significance should be studied. It is a marked feature of the formation at Sharon in Mercer county, where 8′ of white sandstone cover 9′ of pebble rock; and at the fine cliffs of the Cuyahoya river in Ohio.

It characterizes the few exposures which I have happened to encounter in Warren, Venango, and Forest counties. And, so far as I know, wherever the formation contains a considerable amount of pebbles they are vastly more numerous at and a few feet above its base; and also larger.

At Meadville the upper beds are of a rather hard, coarse, dull gray sandstone (often reddish when first quarried), containing an occasional pebble of quartz; but building stone free from pebbles can usually be got by not quarrying down too low.

[* In the Anthracite Coal Fields it is probably represented by the bottom layers of the Conglomerate No. XII underlying the Lykens Valley Coal bed. For a discussion of its relationships in Armstrong, Indiana, Westmoreland, and Fayette, see my preface to Report H⁵, W. G. Platt, 1880, J. P. L.]

The building material obtained from it is quite durable when nothing but the homogeneous sandstone is used; but toward the lower portion, where the pebbles increase in number and begin to be scattered through the matrix, the sand-grains become quite coarse and seem to have little power of coherence, since they rapidly break loose from each other on exposure, and the sandstone soon decays.

The Methodist Episcopal stone church in Meadville seems to have had rock of this character built into many portions of its structure, and the more exposed parts of the building such as the copings, door, and window fixtures, are already showing signs of disintegration. Great care should be taken in putting up a stone structure from this rock that no pebbles enter into the composition of any material exposed to the action of the weather.

In some of the quarries at Meadville 30′ of this upper division is taken out.

The lower division, as seen along the by-road passing up to the quarries, is a perfect mass of quartz pebbles, varying in size from a pea up to a hen's egg, and *always egg-shaped, never flattened* or worn into thin forms such as we often see in the conglomerates which come in the series below this horizon.

The matrix of these pebbles is a coarse greenish-grey sand which disintegrates very readily and lets the imbedded pebbles drop out in a loose heap around the outcrop.

A peculiar lithology, different from that of any other rock in the Conglomerate series, distinguishes the *Sharon Conglomerate*, so that a person who has once learned to know it can rarely fail to recognize it even in scattered fragments; this is especially the case with that portion of the stratum containing most pebbles.

The size of the pebbles seems to increase going east; for the largest seen by me in Crawford county, was not larger than a hen's egg; whereas along the Allegheny river above Tidioute, I have seen many pebbles as large as a goose egg.

The areas surrounded by local outcrops of *Sharon Conglomerate* are shown upon the colored geological map of Crawford county, accompanying this report. The largest

and longest are west of the meridian of Little Cooley and Townville. Between that meridian and the Warren county line, in the upper Oil creek country, only small isolated patches of the rock have been left.

Variability.—These variations of erosion are mostly due to variations in the lithological constitution of the formation; for, instead of being as thick and massive everywhere as it is at Meadville, it changes in many places to a series of thin bedded fine grained sandstones, hardly less capable of resisting erosion than the formations underneath it. It is not unfrequently considerably current-bedded; as for example at Henry's quarry in E. Fallowfield.

Fossils.—And here also the top layer is honey-combed, apparently from the decomposition of the erect stems of a *seaweed* (fucoid);* and it contains also fragments of the scales and bones of *fish.*

The general northern outcrop of the *Sharon Conglomerate* as a formation, or the line along the northern ends of all its separate areas, crosses Crawford county from its southwest corner to its northeast corner, and continues in the same (about N. 63° E) direction to the northeast corner of Warren county.

The elevations above tide along this line increase in that direction.

At the McIntire settlement (*top*), ... 1330′ A. T.
At Meadville, (bar.) 468′ above RR. (*t·p*), ... 1548′
At Garland, in Warren co. (Carll's spirit levels) (*base*), . . 1529′

At Pleasantville in Venango county, It is the 45′ sand in the Ennis well section, No. 21, Report I, Carll, 1875′, p. 35 (*top 1543′.*)

At Fagundus and Tidioute, I saw it as a great pebble rock capping the hills along the Allegheny river.

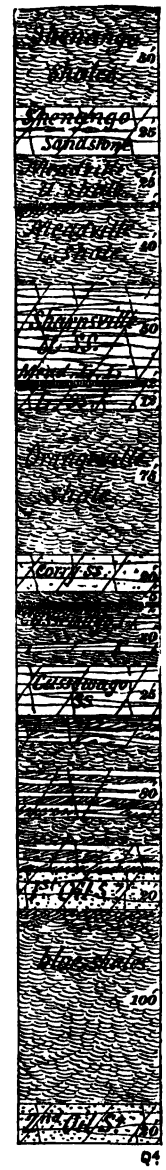
At Franklin I find it in the first massive sandstone above the Franklin quarries, 170′ above French creek, and therefore about 1140′, A. T.

*Remains of *land plants* I have never seen (except as undeterminable fragments) in this rock; although multitudes of *Lepidodendron Gaspianum*, Dawson, (?) occur at Snodgrass' quarry near Jamestown, near the top of the *Shenango shales*, if not confined to them; for, in this quarry the *Sharon Conglomerate* grows flaggy towards its base and passes insensibly down into *Shenango shale beds.*

Generalized section.

SHENANGO,	*Shale,*	50
	SANDSTONE; massive; *fish bed,*	25′
Meadville,	*Upper shale,*	25
	Upper Limestone; fish bed,	1′
	Lower shale,	40′
Sharpsville,	*Upper flags,*	50′
	Meadville Lower Limestone,	2′
	Lower flags,	12′
Orangeville shale,		75′
CORRY SANDSTONE,		20′
CUSSEWAGO,	*Upper shales,*	5′
	Limestone,	2′
	Middle shales and flags,	30
	SANDSTONE,*	25′
Riceville shales,		80′
VENANGO,	UPPER SS. (*First Oil Sand*),	20′
	Upper blue shales,	100′
	MIDDLE SS. (*Second O. S.*),	20′
	Lower shales, red, 15′; blue, 125′	140′
	LOWER SS. (*Third O. S.*),	30′
		310′

7.



Q4

*Mr. Carll has shown how it came to pass that this was named the *First Oil Sand* by the drilling in the Butler Fourth Sand cross belt; the sand below it thereby becoming Second, Third and Fourth sands respectively. Report I.I.I.

CHAPTER VII.

Subconglomerate Formations.

This indefinite term must be applied for the present to a series of deposits underlying the *Sharon Conglomerate* in Crawford and Erie counties, and resting on the *Venango Oil Sand Group.*

The belt of country in which they appear at the surface is exhibited by the light gray color on the geological map accompanying this report.

They make most of the uplands of Crawford county, and a few of those in southeastern Erie; while the valleys between are occupied, and the high divide overlooking Lake Erie is made, by the *Venango Oil Sand Group.*

The generalized section, Fig. 7, given below (in which is included that of the V. O. S. Group), will represent the series pretty accurately everywhere in the region, although innumerable local slight variations occur, both in the character and in the thickness of its several members.

The series may be subdivided into three groups, thus:

SUB-CONGLOMERATE,	*Shenango group*, ... 75′	=442′
	Meadville group, ... 205′	
	Oil Lake group, ... 162′	
Venango Oil Sand group, ...		310′

This or some other such subdivision is called for—

1. By the very peculiar and very wide-spread, coarse, massive and often pebbly, fish-bearing *Shenango Sandstone*, in the upper part of the series, represented by the *Sub-Garland* and *Sub-Olean flat pebble Conglomerate* of Mercer, McKean, and other counties to the east:—

2. By a well-marked sandstone horizon towards the bottom of the series (the *Corry and Cussewago* sandstones), which appears in the oil wells of Venango and Butler coun-

ties as the *Pithole Grit*, and spreads through Ohio as the *Berea Grit.**

Cuyahoga Shale is a name in the geology of Ohio given to all the deposits from the *Sharon Conglomerate* down to the *Berea Grit* (*Pithole Grit, Corry Sandstone*); but this name is objectionable when applied to the upper part of the series in Pennsylvania, because the *Shenango Sandstone* (*Sub-Garland, Sub-Olean, flat-pebble Conglomerate*) cuts the column in two, and separates the *Shenango shales* above from the *Meadville shales* below.

Crawford shale is a name adopted in the Report on the Oil Region (I.I.I, 1880) for all the soft measures pierced by the drillers before reaching the *First Venango Oil Sand*, including the *Big reds* (*Bedford shale*) and the *Pithole* (*Berea Grit*) over it, which is often passed in the oil-borings without noticeable difficulty, as soft flagstones or hard shales, a character which it bears also in Crawford county.

The name *Crawford shales* if retained should be confined to that part of the *Cuyahoga series* beneath the *Shenango sandstone* and above the *Corry sandstone*, a vertical interval of say about 200′; but, as this interval contains the Meadville limestones, which have played so distinguished a role in settling our northwestern State geology, the name *Meadville Group* may replace that of *Crawford shale* entirely.

The *Waverly formation* of Southern Ohio occupies the same general horizon as this series, its quarry rock being the Berea Grit.†

The Pennsylvania names *Mauch Chunk shale, No. XI,*

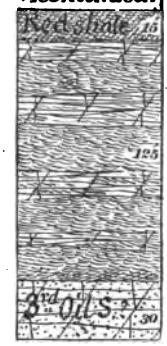
[* Another element of classification is to be found in the remarkable deposit of red shale at the bottom of the series, confined to a belt of country extending, in a great curve, through Forest, Venango, southern Mercer, northern Butler, and Lawrence counties, in Pennsylvania, through the State of Ohio to the lake shore west of Cleveland. This deposit is called the *Big Reds* by the oil well drillers, and the *Bedford shale* by the Ohio geologists; and it overlies the *Venango First Oil Sand.*—See map of this red belt in Report I.I.I, Carll, 1880, Chapter VIII, p. 91, FF.—J. P. L.]

† Hitherto much confusion has characterized the application of the term *Waverly*, and it has therefore not been used in the Pennsylvania reports. One re-adjustment of its divisions is given by Prof. Ed. Orton, in the Amer. Jour. Science for August 1879, p. 139.

Pocono Sandstone No. X, and *Catskill* No. IX, cannot be used with safety in this report because the great formations which they designate in Middle and Eastern Pennsylvania are much thinned and changed in character before they reach Crawford county. It is not certain that No. XI exists at all in the Lake region, although it seems to be recognizable in Clarion county and in Beaver county.* There are reasons for believing that the *Venango Oil Group* in its upper part is *Catskill* No. IX; but there are also reasons for considering it in its upper part *Pocono*, No. X.† There is very little room to doubt that the series to be described in this chapter *as a whole* represents the *Pocono*. The questions left unanswered are: 1. Does the *Shenango shale* at the top represent the *Mauch Chunk* No. XI? and 2. Does the *Big Red* (*Bedford*) at the bottom represent *lower Pocono*, or *Catskill?* But the question is of no practical importance in this report.

The local names given to the beds and groups of beds in the series, with their thickness (observed, or estimated, or averaged as the case may be), are given in the generalized section, Fig. 7, the first part of which is given on page 66.

7.continued.



The section at *Sharon* in Mercer county (Fig. 8,) and the section at *Beaver Falls* in Beaver (Fig. 9,) published in Report QQ, p. 297, 298, 303, show the persistence of these subdivisions of the series southward.

* See Preface to Report H⁵, 1880. Also Report R, 1880.
† See Report G⁴, 1880.

Sharon section, for comparison, Fig. 8.

SHARON,	*Coal*,	4′		
	Fireclay and shales,	5′		
	CONGLOMERATE,	20′		29′
SHENANGO,	Shales,	45′	55′	
	SANDSTONE,	10′		
Meadville shales, sandy,		80′		
Sharpsville flags,		40′		378′
	*Drift** (rocks invisible),	43′		
Orangeville "Blue slate,"		85′		
CORRY, CUSSEWAGO, "Sandstone, white, sharp,"		75′		
Riceville and VENANGO	"Light blue shales,"	†305′		335′
	SANDSTONE, grey, fine, *Third Oil Sand*, (I. C. W.,)		30′	
Chemung, *Girard*, *Portage*,‡	"A succession of blue, grey, and brown shales, interspersed with thin layers of grit to bottom (1600′).			1005

Beaver Falls (Economy Well) Section, Fig. 9.

Down to base of Lower Connoquenessing SS.		210′		
Sharon,	Shales, brown,	40′		279′
	Sandstone and slate, brown,	24′	69′	
	Sandstone,	5′		
Shenango,	Shale, light,	1′	21′	
	Sandstone, brownish yellow,	20		
Meadville?	Shale, dark, sandy,	40′		
	Sand, mixed with shale,	5′		
	Shale, sandy,	10′		
	Shale, light colored,	75′		
Sharpsville?	*Sandstone*, light grey, fine,	40′		
Orangeville?	Shale, dark, sandy,	12′		425′
	"Shell" [harder rock,]	5′		
	Shale, dark, sandy,	25′		
	Shale, brown, sandy,	18′		
	Shale, soft,	7′		
	Shale, sandy,	3′		
CORRY?	SANDSTONE, white,	20′		
CUSSEWAGO?	Shale, brown, sandy,	10′		
	Sandstone, brown,	20′		
	SANDSTONE, white, pebbly,	124′		
Venango,	Shale, dark, sandy,	10′		396′
	Shale, blue,	82′		
	Shale, olive,	143′		
	Shale, red,	15′		
	Shale, dark,	116′		
	SANDSTONE, hard, gray, (3d O S.),	30′		

* Well mouth commences 57′ above the top of the *Orangeville* blue slate.

† Not 30′, as in QQ, p. 298. ‡ The well must have sunk into the Portage about the depth exposed on Lake Erie shore at the New York line, say 475′.

Fig. 8. Section of the rocks exposed in the vicinity of Sharon, and bored through at Sharon furnace, Mercer County, Pa.

Fig. 9: Section of the rocks passed through in the well boring at Beaver Falls, Beaver County, Pa.

Fig. 8.

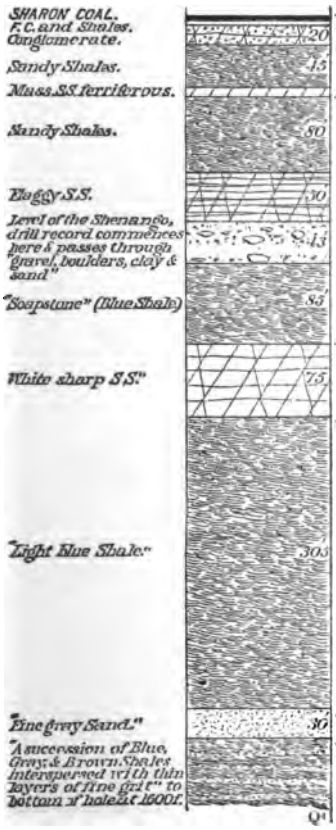
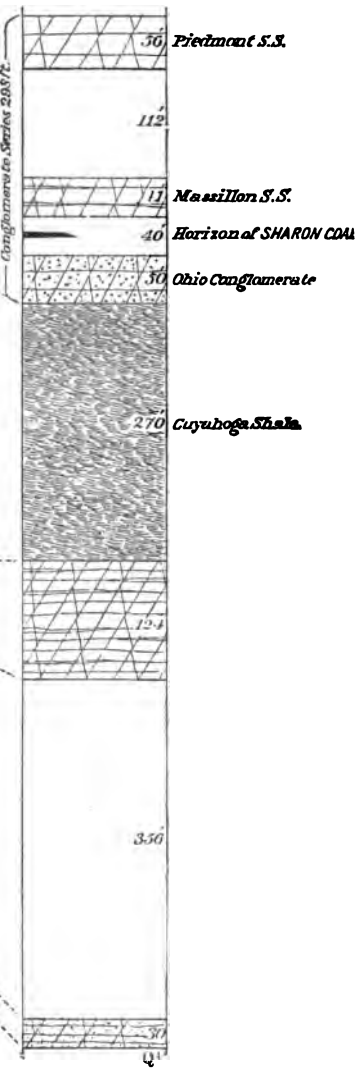


Fig. 9.



Chemung, *Girard*, *Portage*,	Alternations of thin sands and sandy shales, with soft shales (but no black slates) to bottom (2330′), ...	1240′

My section of the exposures in the *Tidioute* bluffs, (Fig. 10,) shows their persistence eastward.

Tidioute Bluff Section, Fig. 10.

SHARON CONGLOMERATE, ...			30′	
SHENANGO,	Shale, ... 60′		80′	
	SANDSTONE, massive, ... 20′			
Meadville Shales (and concealed), ...			100′	
Sharpsville,	Upper Sandstone, seen, . . . 30′		41½′	403½′
	Meadville Lower Limestone, 1½′			
	Lower Sandstone, ... 11′			
Orangeville,	Shales, soft, blue, ... 22		49′	
	Flags, ... 27′			
CORRY SANDSTONE, ...			10′	
Cussewago and Riceville,	Shales, chocolate, and concealed, . .		123′	
VENANGO,	I.	SS., massive, ... 13′	37′	326′
		Shale, ... 9′		
		SS., massive, ... 15′		
		Shales, red, and sandstones, . .	90′	
	II.	SS., massive, ...	25′	
		Shales, blue, ...	5′	
		Concealed to river, ...	20′	
		Concealed beneath river,* . . .	100′	
	III.	SS., average, say*	50′	

The *Meadville Lower Limestone* is a fortunate key to this section, and to the geology of the surrounding country. The *Upper Limestone* may also be in its place, but concealed by the surface slides.

One more section will suffice to show the normal arrangement of these subconglomerate rocks, taken as a whole.

A bore-hole was drilled at Oil Creek Lake, on the bank above the water tank, at 1420′ A. T. The *Corry Sandstone* is quarried in a ravine, distant a few rods from the bore-hole. The driller Mr. S. L. Dobbin's record is as follows:

* Estimated from Mr. Carll's well records, Report I.I.

Oil Lake bore-hole Section. Fig. 11.

CORRY SANDSTONE,		10′	130′
Oil Lake Shales, and concealed to top of hole,		76′	
(Conductor) *Drift*,		14′	
Cussewago "*Sandstone*, very hard,"		30′	
VENANGO,	"*Red shale* at 207′ down,"	331′	340′
	"Slate,"		
	"PEBBLY SAND," some oil,	9′	
	Third Oil Sand (I. C. W.),		
Chemung,	"Slate,"	146′	266′
	"Sand shells frequent in this interval, some 3′ thick; one with pebbles at 594′ down,	120′	
Girard, "Soft slate,"			262′
Portage,	"Sand shells, very hard,"	20′	98′
	Slate, soft to bottom (1000′),	78′	

From the base of the Sharon Conglomerate down to the base of the Third Oil Sand, as I recognize it in the above sections, the distances are as follows:

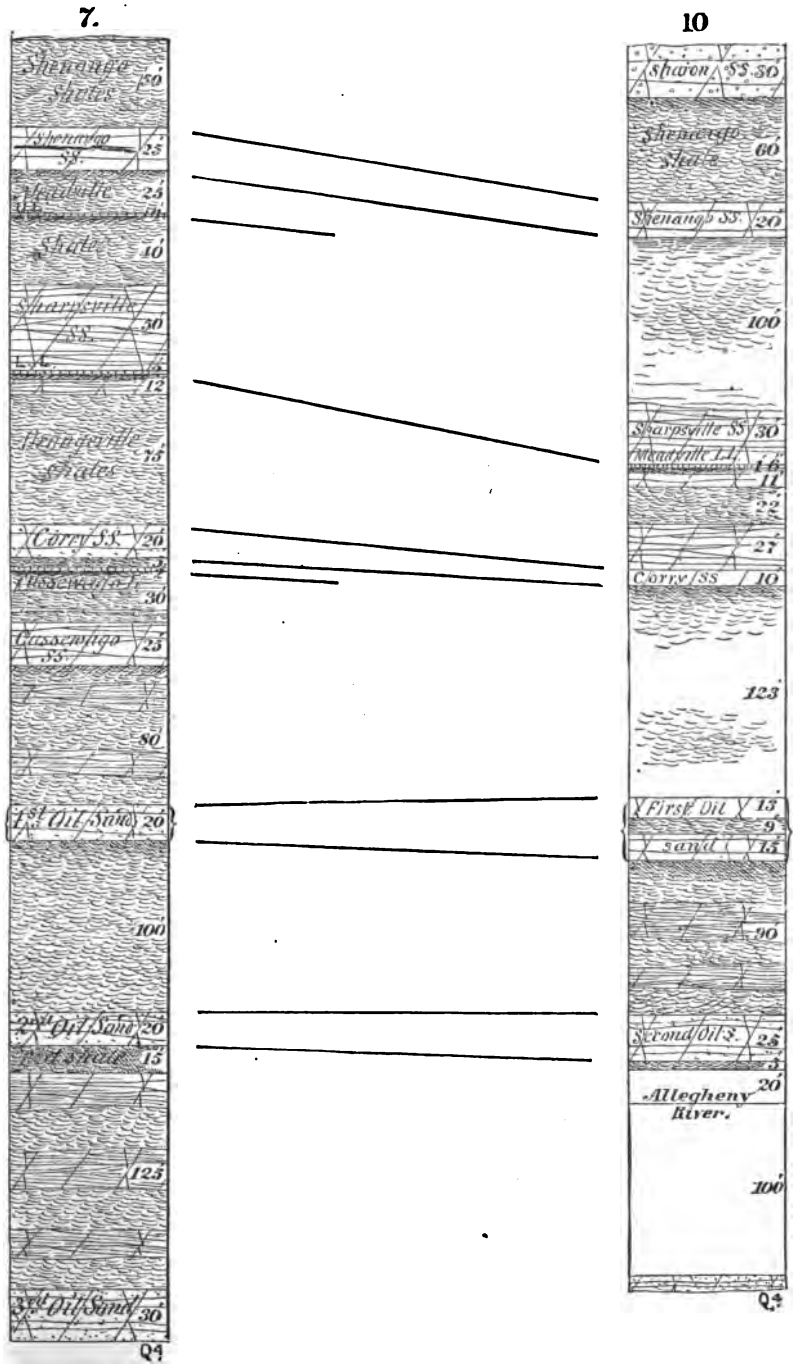
Generalized Section, Fig. 7,	752′
Oil Lake Section,* Fig. 11,	750′
Tidioute Section, Fig. 10,	732′
Sharon Section, Fig. 8,	716′
Beaver Falls Section,† Fig. 9,	780′

There is, no doubt, above the upper limit of the sections, the *Sharon Conglomerate*, which I have traced continuously from point to point, except in the Beaver Falls Section, where I now think it may perhaps be wanting.

The Sandstone zone some distance above the *Venango First Oil Sand* is a marked feature in these sections, although very changeable in thickness and detailed character. It is, however, a persistent horizon, and represents the *Berea Grit* of Ohio, and the *Pithole Grit* of Venango. It is undoubtedly an extension westward of one of the heavy, massive deposits of the Pocono Formation, No. X. See Report on Blair county, T, 1881, and probably of the great conglomerate strata of the lower part of its middle member, in Huntingdon county. See Report F, p. 211, 1878.

*280′ added above for estimated amount of erosion; the Cuyahoga shale series, as a whole, being of normal thickness in this vicinity, as my local sections show.

† Six miles from the Ohio river and 40 miles south of the Sharon section.


7.
10
Shenango Shales
50
Shenango SS.
25
Meadville
25
Shale
10
Sharpsville SS.
30
12
Deangerville Shales
75
Corry SS.
20
Cassewago
30
Cassewago SS.
25
80
1st Oil Sand
20
100
2nd Oil Sand
20
15
125
3rd Oil Sand
30
Q4
Sharon SS.
30
Shenango Shale
60
Shenango SS.
20
100
Sharpsville SS
30
Meadville LL
16
11
22
27
Corry SS
10
123
First Oil
13
9
sand
15
90
Second Oil S.
25
5
20
Allegheny River.
100
Q4

The shales which underlie this Sandstone zone are, at Oil Lake 331′, at Sharon 305′, at Beaver Falls 356′ thick, and in them we should find the Venango First and Second Oil Sands; but these are wanting over the greater part of Crawford and Erie counties, or only represented by soft flagstones, not recognized as "sands" by any driller. Their normal places, however, are given in the generalized section (Fig. 7) not to deceive but to guide the reader.

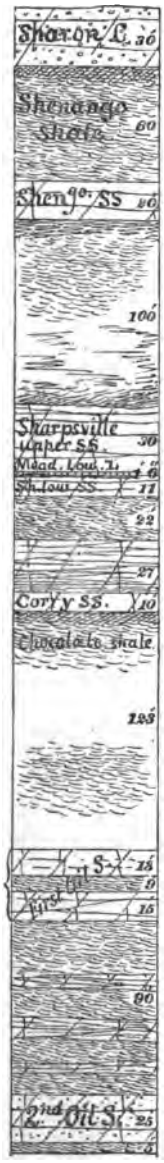
It must be distinctly understood that the Venango First and Second Oil Sands are of no account in Crawford and Erie counties. But the *Venango Group as such* is traceable through the region, not only by its relation to the *Corry and Cussewago Sandstone* zone above it; by its persistent thickness of between 300′ and 350′; but also, and especially, by a massive sand and sometimes gravel deposit at its base, which can be nothing else than the *Venango Third Oil Sand;* beneath which there is nothing but shales for hundreds of feet, (as under the pebble rock of the Oil Lake well,) or 1000′, (as under the hard grey sandstone of the Sharon well,) or 1200′, (as under the 30′ sandstone of the Beaver Falls well,) or even more, as in all the deep wells of the Oil region.

Note.—Mr. J. T. Hodge, Assistant of the First Survey, in 1837 made the following statement which may be found, substantially, in the Third Annual Report of the State Geologist, p. 111.

"A reference to the stratification, as we behold it in the vicinity of Meadville, will tend to convey a tolerably exact conception of the nature of the beds of rock which occupy the 400′ of depth below the base of the conglomerate stratum (formation XII) which there caps the hills forming part of the general margin of the coal field.

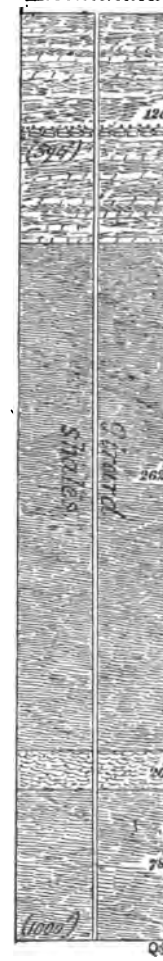
"These hills on the north and south of the town are at their greatest elevation 488′ above the bottom of the canal, and expose the upper strata especially with some degree of

10.



11.

11.continued.



distinctness. The lower ones are not so continuously exposed to view, making it more difficult to determine their true order of succession.

"Near the level of the canal, the beds are of brown slate and sandstone, and over this we find a thin bed of clayey shale, then a sandstone repeated, and then another layer of *red and grey shale* 2′ or 3′ thick.

"Near the outcrop of this bed of clayey shale a spring issues, near its upper surface, encrusting all the rocks beneath it with a coating of carbonate of lime.

"At a higher level are seen thin beds of *calcareous shale*, some of which abound in *fossil shells* and other organic remains.

"From this shale to a height of 150′ occur alternations of coarse brown sandstone and thinly laminated bluish slates and flaggy olive sandstones and olive slates.

"At that height we meet a bed of blue shale 4′ thick, and over it a brown sandstone and olive slate, until we reach 235′ (above the bed of the canal.)

"Here we encounter a bed of *sandy limestone*. . . . . [See Meadville Lower limestone described below.]

"Under the limestone, in a massive bluish sandstone, we find thin layers of an impure *iron ore*.

"Ascending from the limestone, we pass thick beds of brown and bluish sandstone, (some of which latter are slightly *calcareous*,) thin beds of *fossiliferous* and *calcareous* slate, succeeded by others of brown and blue shale.

"At the height of 412′ we arrive at the base of the great bed of (Sharon) Conglomerate, consisting of sand and siliceous pebbles, never larger than a common marble or a large pea. The same rock is seen at the height of 450′. Its soil is different from that of the rocks beneath it, being said to be better fitted for wheat, and sustaining a luxuriant growth of chestnut trees."

CHAPTER VIII.

Shenango group.

In Ohio the interval between the base of the (*Sharon*) CONGLOMERATE and the *Berea Grit* is occupied by (*Cuyahoga*) shales.*

In Pennsylvania, a sandstone makes its appearance among these shales, not far from their upper limit.

This sandstone is traceable from Sharon northwards along the Shenango valley to Jamestown, and thence across Crawford into Warren and McKean counties where it is an important conglomerate rock of strongly marked character.†

The shales above it are a distinctly separate formation, including in the eastern counties black slate and some thin coal seams, red shale, and beds of iron ore.

The shales below it graduate eastward into the *Pocono* (*Vespertine*) flaggy sandstones; as the sandstone itself does, going southward from McKean into Elk, Cameron and Clinton counties.

The Pocono Formation, No. X, therefore, *in its upper portions*, is represented in Crawford county 1. by the *Shenango sandstone*; 2. by the *Cuyahoga shales proper*, down to the *Berea Grit* (*Corry, &c.*)

The only question at all open is whether the *Shenango Shales* (*above the Sandstone*) are also to be considered *Pocono* (*Vespertine*) *No. X;* or whether they are a true continuation into Ohio of the *Mauch Chunk* (*Umbral*) *No. XI.*

* This is the case in Medina, Lorain, Ashland, Knox, and Licking counties, where they are said to be 250′ to 300′ thick; about the same as in Crawford county, Pennsylvania. But in Trumbull county, Ohio, the Sharpsville sandstone has been mistaken for the Berea, and 100′ of measurement therefore lost. In Ashland, Mr. Read's "Olive Shale" is called 270′ thick (Geol. Ohio, III, 523) down to the "Waverly Conglomerate;" which again agrees with my measurements in Crawford county down to the *Corry sandstone.*

† The *Sub-Garland conglomerate* of Mr. Carll; the *Sub-Olean conglomerate* of Mr. Ashburner.

This question cannot be answered at all in the State of Ohio nor in Crawford county; nor with any certainty even a far east as McKean and Clinton counties, where Mr. Ash burner advocates the former and Mr. Chance the latter view and both of them with reasons not to be despised.*

Shenango Shale.

The Shenango shale deposit, under the *Sharon conglomerate*, in Crawford and Erie counties, generally consists entirely of blue, gray and brown clay-shales, but frequently contains thin flaggy sandstone layers, which in one locality I saw merge into a solid 10′ sandstone.

A streak of iron ore is almost always found at the base of the shales, in Crawford county; an irregular layer of clay iron-stone balls.

Fossils rarely appear in the *Shenango shale.* When found, they are of Sub-Carboniferous types; badly preserved *Productus*, *Allorisma*, *Straparollus*, and *Spirifer*

Lepidodendron Gaspianum, or a closely allied plant, has furnished abundant remains to the upper part of the *Shenango shale* at Snodgrass Quarry, near Jamestown.†

Lepidodendron Weltheimianum, or some closely allied form, is also seen there.

The thickness of the Shenango shale, when well exposed was nowhere less than 36′, nor more than 60′. Near Sharon in Mercer county, on the Ohio line, it measures 47′. At Tidioute, in Venango county, I found it 60′, and near Kinzua, in Warren county, about 45′.‡ Its average through Crawford county may be called 50′. In Erie county, its bottom layers (if any) are left on the highest hilltops.

The outcrop of the *Shenango shale* is marked upon the geological map *in red*, with a sharp *inner edge* at the *Sharon Conglomerate*, but an indefined *outer edge* where it overlaps the *Shenango sandstone.* This red color is proper to the *Mauch Chunk Formation No. XI.*

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* See Reports R, and G 4, 1880.

† This is the only locality where any plants have been seen in these shales.

‡ Judging from the fact that from its top down to the base of the Shenango sandstone (*Sub-Olean Conglomerate*) was 90′.

Shenango Sandstone.

*Ferriferous sandstone, Report QQ, 1878, p. 95.**
Sub-Garland Conglomerate of the Oil Region reports.
Sub-Olean Conglomerate of the McKean, &c., reports.
Upper Pocono Sandstone (Vespertine) No. X.

This remarkably persistent, wide-spread and characteristic deposit, differs so much from all the other sand deposits of the region that it cannot be mistaken. I discovered its importance along the Ohio line in 1876, and traced it northward and eastward from Sharon, in Mercer county, through Crawford into Warren and Venango and to McKean counties, where in 1879 I identified it at Franklin, Tidioute, Warren and Kinzua, with the first sand rock under the *Sharon-Garland-Olean Conglomerate.*

In Crawford county it is always a sandstone, tolerably coarse in grain, yellowish brown or sometimes dull grey in color, crowded with balls of iron ore from 1″ to 1′ in diameter, or even larger.

Fish bones, teeth, scales and spines are everywhere found in it; often scattered through it in great numbers, usually badly broken and rubbed, and often mere blotches of bluish-white matter on the weathered surfaces of the rock; neither specific nor generic characters recognizable.

Small rounded pebbles of shale, or fine hard sandstone, are common in it.

Small pebbles of a soft ochery substance are not unusual.

Two plants are to be discovered in almost all its exposed outcrops; the most common one closely allied to, if not identical with, *Lepidodendron Gaspianum*, Daws,† the other, less common, *Lepidodendron Weltheimianum*, St.

Shells are occasionally found in it, but generally broken and unrecognizable, at least specifically. I have however found specimens of *Orthis*, *Spirifera*, *Discina* and *Pro-*

* This name which I at first gave it, locally, before I knew its geographical importance, was almost everywhere corrected out of my report on Lawrence county, and never used afterwards.

† Figured from the *Pocono (Vespertine) Formation No. X*, of Eastern Pennsylvania, in Geology of Pennsylvania, Vol. II, plate 21. See description l. c. by Lesquereux.

ductus of forms apparently different from those of the *Mauch Chunk* (*Umbral*) *Formation No. XI.*

As a building stone it is very valuable; far superior to the *Sharon Conglomerate* above it, in resistance to weather,* which is explained by the fact that it is composed of nearly a pure *quartz sand*, the grains cemented by peroxide of iron. Its ore-balls, however, are so numerous, that it is almost impossible to dress up the blocks, which are therefore rejected for ornamental uses, and used almost only for bridge abutments, piers and other strong structures. Those in the locks of the old Beaver and Erie canal are as sound and the chisel marks as sharp as when laid fifty years ago.

Jackson's quarry, between Atlantic and Evansburg, has furnished most of the bridge stone, &c. along the Atlantic and Great Western railroad.

Its outcrops are to be found on the geological colored map of this report by referring to the *outside edge* of the red color surrounding the areas of *Sharon Conglomerate*, and at various distances beyond the red color.

The outcrop enters Crawford on the east bank of the Shenango river, runs to the center of S. Shenango township, then east through W. Fallowfield and returns back of Adamsville, 250′ above the level of Crooked creek.

It runs north and south through E. Fallowfield, overlooking the railroad; circles at Stony Point through Sadsbury back into E. Fallowfield, and so follows the south hills of Conneaut Lake creek through Greenwood and Fairfield and down French Creek valley into Venango county.

It encircles the high lands in Vernon, and in Union, about 250′ above the level of Conneaut Lake creek.

It runs along the Meadville hills, at about 375′ above the level of French creek.

It looks down from the south and west upon the great bend of Woodcock creek, along the north and west lines of Randolph.

It stretches from around the hill tops of New Richmond southward into Venango county, east of Sugar Lake, and through Troy township.

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* It can also be more cheaply quarried than the Sharon Conglomerate.

It occupies the high summits of northern Adams west of Riceville on Oil Creek; of western Sparta, and east of Oil Lake, and enters Warren county east of Mill Pond.

In Erie county it caps two or three isolated knobs in Concord township.

Here it is 1860′ above tide; at Snodgrass' quarry near Jamestown only 1190′; distance about 46 miles; rise 670′; *rate of rise* (say N. 33° E.) *14½ feet per mile.*

The thickness of the Shenango Sandstone in Crawford county varies from 15′ to 35′. At Sharon, in Mercer county, it is 7′; in the Brookfield tunnel, near Sharon, only 3′; but perfectly typical in character.

Natural exposures of considerable beauty may be found in two localities: viz.—In Greenwood, half a mile south of Glendale, fine cliffs enclose a deep and narrow gorge, with a waterfall 30′ high. Here immense quantities of ore balls may be seen, many of them larger than ostrich eggs; base of rock, 1270′ A. T.

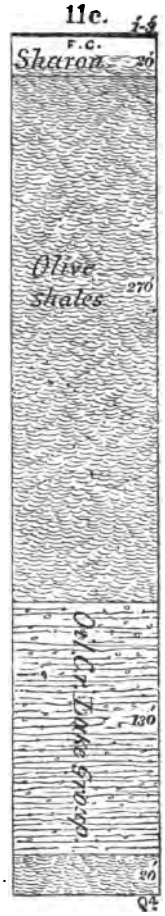
In Wayne, Grassy run (a branch of Little Sugar creek), ¼ mile above its mouth, cuts a chasm through the rocks; with cliffs, 35′ high; base of rock, 1315 A. T.

Hundreds of other inferior natural out-crops might be enumerated.

As the Shenango Sandstone is followed eastward it becomes coarser and more massive. At Meadville its bottom layers begin to be pebbly; at Garland, in Warren county, its bottom layers are quite pebbly;* at Warren, it is from 40′ to 45′ thick, and a pebble-rock throughout; at Franklin, it is extensively quarried 120′ above the water in French creek; at Tidioute, 60′ beneath Triumph hill conglomerate 500′ above the river; at Kinzua, 540′ above the river. In all these places I have recognized and studied it.

Everywhere all its pebbles have the marked peculiarity, first noticed by Mr. Carll, of being flat or flatish, not round as in the Sharon-Garland-Olean conglomerate above it; and the same holds true all over McKean and adjoining counties to the eastward.

**Base* 120′ beneath the *top* of the *Sharon-Garland-Olean* Conglomerate.


11c.
F.C.
Sharon 20
Olive Shales 270
Q4

11b.
Drift 10-30
Corry SS (Berea Grit) 30
(Cleveland) Shale 65
(Erie) Shales 132
Lake Erie. Q4

11a.
Sharon C.
Shen. SS.
SS.

Chapter IX.

Meadville Group.

Meadville Upper Shales.

These are bluish gray, or ashen gray in color, argillaceous at the top, sandy lower down; sometimes flaggy, but never massive.

Thickness where well exposed at the head of the Cemetery branch of the Mill run, near Meadville, 15′; one mile east of this, 30′; on Grassy run, in Wayne, 36½′; at Glendale, 30′; at Jamestown, 25′; near Dutch hill, in Union, 40′; in E. Fallowfield, where the road crosses Unger's run, 15′; at Franklin, in Venango county, 20′, &c.

Fucoids, or sea-weeds, are numerous in these shales.

Meadville Upper Limestone.

This rock, which I found in 1879, has served me well as a key to the geology of the region. It is exposed in many places across Crawford county, and I found it at Franklin 20′ under the *Shenango Sandstone*. Its thickness seldom exceeds 1′ (one foot), often not 6″, and never more than 1′ 6″.

Fish scales, teeth, bones, plates, and spines are so crowded in it, that at many localities it might be called a *fishbone conglomerate*, in which it is difficult to detect any other materials.

Scales of *Palæoniscus* are the most abundant; and hundreds of them cover every slab. *Cladodus*, *Orodus*, *Lambdodus*, *Mesodmodus*, *Stemmatodus*, and others are of frequent occurrence. Spines of *Ctenacanthus*, *Drepanocanthus*, and *Bataeanthus* also occur. (One specimen was apparently identical with *B. baculiformis*, St. J. and W.)

Spirifera, *Streptorhynchus*, *Orthis*, *Productus*, *Discina*, *Rhynchonella*, *Conularia*, and *Orthoceras* frequently

abound in it. They seem to be mostly of undescribe species; but the *facies* is most nearly like that of the Kin derhook fauna of the Mississippi valley, although some re semble Keokuk and Burlington types.

From an inspection of a collection sent to Prof. A. H Worthen, State Geologist of Illinois, he opposed this opin ion, and was inclined to regard the fish as rather of Cheste Limestone aspect.

Prof. Orestes St. John, of Topeka, to whom Prof. Wor then submitted at first a small collection, also recognized Chester facies, but noticed some Kinderhook affinities.

On receiving a larger and better collection, Prof. St. John expressed an opinion in favor of the lower rather than o the higher horizon.

From all the evidence, I am inclined to an equivalency with the Lower Keokuk or Upper Burlington fish beds, in preference to the Kinderhook. There are certainly many novelties in this Meadville Upper Limestone, and material for its study are abundant and easily accessible.

Rounded pebbles of shale and fine sandstone are nearly always to be found in it; usually of a dark color, and de rived from some older strata of the series. In some places these pebbles are immensely numerous. They are usually flat or lenticular, sometimes worn oval, and tapering to a blunt point.

The Limestone matrix is not a pure carbonate of lime but contains much silica, &c., and often resembles a sand stone weathered. The rock has the peculiar sub-carbonif erous-limestone fracture of this region, the broken surface being covered with many small elliptical, glassy, sparkling spots (which look like small shells until they are closely examined) due to a semi-crystallization of the carbonate of lime.

The best places to study this rock and to collect its fossils are as follows:

The gorge south of Glendale; the ravines east of Mead ville leading into Mill run; the ravines 2½ miles east of Meadville descending to Woodcock creek; Grassy run, in Wayne township, a very fine locality; the bluffs of French

creek at Franklin; the ravine at Jamestown; and at McElhenny's, 2 miles north of Jamestown.

Good exposures can be found on the numerous small streams descending to Adamsville; but fish remains can be found almost anywhere on all the lines of out-crop.

Meadville Lower Shales.

These shales are, like the upper, generally ash-grey and blueish, sandy, alternating with sandy flags increasing in number towards the bottom.

The thickness may be said to average about 40′, although it sometimes reaches 60′.

The out-crop extends little beyond that of the *Shenango Sandstone*, because the latter was its only protection from erosion.

Fucoids are numerous (as in the upper shale) and badly preserved *shells*, evidently *Spirifers*, *Producti*, *Allorismæ*, *&c.*

Sharpsville Sandstone.

The sandy deposits at Sharpsville underlie the shales at Meadville; and in some places the increase of muddy material upward is the only limiting circumstance.

After my study of the persistency of the bed of limestone which lies in the body of the sands, I distinguished those above and below as *Upper and Lower* (*Sharpville*) *sandstones*. But apart from the limestone they form together but one deposit of sand, which I traced in 1876 along the Shenango and Pymatuning creeks into Vernon township, Trumbull county, Ohio. Here I found it called by Mr. Read *Lower Berea*; my *Shenango Sandstone* above it being called *Upper Berea*. But the *original Berea Grit* of Medina, Lorain, Ashland, and Richland counties of Ohio, under the *Cuyahoga Shale formation* of Ohio, lies from 270′ to 300′ beneath the *Ohio Conglomerate*; whereas this *Sharpsville Sandstone* ("Lower Berea") lies only 145′ beneath the *Sharon* (*Ohio*) *Conglomerate*, and we must look 100′ lower for the genuine Berea, viz: in the *Corry and Cus-*

*Geol. of Ohio II, 505.

sewago sandstones of the Oil Lake group (the *Pithole gr* of the Oil regions.) And this being done the *Cuyahoga sha series* is relieved of its supposed variability and shows constant thickness of about 300′ all over northern Ohio an northwestern Pennsylvania, as may be seen by sections o pages 70, 71, 72, above.

To illustrate the case, I give the following section whic I made in Vernon township, 3 miles north of Orangeville in Ohio.

SHARON (OHIO) CONGLOMERATE, very pebbly,*	25′
SHENANGO, *Shale,*	50′
SHENANGO, SANDSTONE, (Read's *Berea Upper S.*)†	15′
Meadville shales,	80′
SHARPSVILLE SANDSTONE, (Read's *Berea Lower S.*)‡	60′
Concealed to the level of the Pymatuning creek,	110′

Sharpsville Upper Sandstone.

Layers of fine bluish-gray or greyish-brown flagstone from 1′ to 2′ thick, alternate with thin layers of greyis shale. Rarely the shale amounts to one third of the mass often to so little that the flags are almost a solid series.

Quarried in districts destitute of better stone, this depos affords building materials for cellar walls and other roug work.

Good building stone is got from one 3′ layer just south c Atlantic station ; also near Jamestown at the county line also at Miller's 2 miles northwest. Its somber hue is di liked.

Rhynconella, *Allorisma*, *Spirifer* and *Productus* shell poorly preserved, are usually found in it. I found a larg *Ctenacanthus* fish-spine in it, in Mercer county.

The thickness of the *Sharpsville Upper sandstone* mas in Crawford county is about 50′.

Its outcrop ranges considerable north of that of the *Sh nango sandstone*, but not far enough to cross the Erie count

* The *Sharon coal* overlies the Conglomerate close by.

† Upper green line on Reed's map of Trumbull county.

‡ Lower green line on the same. This out-crop of the rock I traced co tinuously from Sharon, where it rises from the water, up the Shenango an Pymatuning valleys, by two lines, to the same point in the northern line Trumbull county, Ohio.

line, except at its east end, where a few isolated knobs in Erie county hold it.

Meadville Lower Limestone.

This thin bed of impure limestone lying 235′ above the level of the level of the canal* at Meadville is as remarkable a geological horizon as the *Meadville Upper limestone* already described.

Wedged in between the *Sharpsville Upper and Lower sandstones*, weathering like them, and covered by their fragments, I saw nothing of it at first in my survey of Mercer county.

Seldom more than 2′ thick, and often only 1′, it is nevertheless so persistent, that I found it in every part of Crawford county; afterwards in Mercer county, along the Shenango valley for 21 miles, to where near Sharon it goes beneath water level; on the Allegheny river, rising from water level between Franklin and Oil City; cropping out all along the west bank of Oil creek at 1173′ A. T.; and at Tidioute 375′ above the Allegheny river bed; and represented, perhaps, by fragments on the Brokenstraw, at Garland, 135′ beneath the *Shenango sandstone.*

From the base of the *Sharon Conglomerate* down to the *Meadville Lower limestone*, I make the interval, in Crawford county, never less than 190′. Mr. Randall's section at Warren (Report I, Carll, 1875,) places a limestone 200′ beneath the base of the *Garland (Sharon) Conglomerate.* At Tidioute I make it 210′. †

This limestone is very hard and flinty, breaking with the same peculiar fracture mentioned already in the description of the *Meadville Upper limestone.* "It lies," says J. T. Hodge, who first described it, "in large and nearly square masses, the angles of which are more or less rounded off, showing the readiness with which the lime is dissolved out of the rock. By the removal of this ingredient, and the

* J. T. Hodge, 1837, in Third Annual Report of H. D. Rogers to the Legislature, p. 111.

† See Geology of Pennsylvania, 1858, vol. II, pp. 548, 549, for the limestone at Smethport 200′ below No. XII.—See Report R, McKean county, Ashburner, 1880.

oxidation of the iron in the stratum, it acquires a brown siliceous crust, sometimes thick, indicating it is to be feared too large a proportion of sandy matter, to qualify this rock to be converted even into an impure lime. In an attempt once made, the excess of sand in the rock produced with the lime a slag."* This feature characterizes also the Cussewago limestone to be described further on.

The hardness of these limestone beds compared with that of the measures enclosing them cause little water-falls in the beds of the streamlets, descending the hill slopes; and in some places the water flows over the limestone stratum for a considerable distant above such a cascade.

Non-fossiliferous, in Crawford county, as a rule, this *Lower* Meadville limestone, differs in a striking manner from the *Upper* one. At one or two localities only I found a few *fish scales* and *Linguloid shells*. But in Warren county at Garland, and in Venango county at Tidioute, it is a perfect *mass of broken shells*, misshapen *Spirifers* and unrecognizable other forms. At Tidioute the shell lime is bleached white, and has been popularly mistaken for quartz. *Spirifer disjuncta* (or some allied species) is most common.

A very good and nearly pure *white lime* has been made from this stone in certain exceptional localities in Crawford county. On Deckard's run it was once quarried to a considerable extent by Mr. Shuey and burned into *plastering lime*. As flux for Liberty Furnace, mixed with *Lower Mercer Limestone* from near Utica, it was a failure.

Analysis, by Dr. F. A. Genth,† of a more than ordinarily siliceous specimen:

Carbonate of Iron,	3.62
Carbonate of Manganese,	0.31
Carbonate of Magnesium,	1.70
Carbonate of Calcium,	27.61
Alumina,	4.24
Silica,	60.43
Water,	1.74
Total,	99.65

* In Prof. H. D. Roger's Third Annual Report to the Legislature, 1838, p. 111, 112. Repeated in Geology of Pennsylvania, 1858, vol. I, p. 584.

† For Mr. Carll.

Judging from the appearance of specimens the silica is *usually* not more than 20 per cent. of the whole.

Out-crops excellent for study may be found in Crawford county, near Jamestown, in the hollow down from the bridge below Snodgrass's quarry; near Meadville, in the cemetery grounds, at the hydraulic ram on Mill run; at Geneva, Greenwood, bed of run just west of RR. station; in Hayfield township, west branch of Cussewago creek, heads of ravines; in Mercer county, opposite Sharpsville, in the banks of the Shenango; in Venango county, in the bluffs opposite Oil City; and in Warren county, in the north river slopes at and below Tidioute.

Sharpsville Lower Sandstone.

This is a series of 6″ to 2′ flags exactly like those above the limestone.

Its usual thickness is from 10′ to 12′; in one place 30′.

Orangeville Shales.

These bottom deposits of the *Cuyahoga formation* of Ohio*—120′ thick on the Shenango river at Sharon, 120′ thick on Cussewago creek, usually 100′ throughout Crawford county, and in very few places less than 60′—are generally dark bluish shales (with a few scattered thin layers of sand,) often holding small lenticular nodules of clay-ironstone, but more commonly weathering brown from disseminated iron.

Lingulæ and *Discinæ* in great numbers, and a few *fish remains* are its only fossils, and are distributed from top to bottom; but more abundantly toward the bottom. The species being Cuyahoga forms:

Lingula melia, Hall.

Lingula membranacea, Winchell.

Discina pleurites, Meek.

Discina Newberryi, Hall.

I have never seen these species in any of the underlying rocks, although another very different species of *Lingula* is common in the underlying *Corry sandstone.*

* See Report QQQ, foot note to p. 63.

At Tidioute, where only 22′ of characteristic shales are represented, the rest of the interval being occupied by sandy flagstones, I could find hardly any of these shells.

At Trumbull county, Ohio,* on the contrary (at Warren, O.) they are more numerous even than in the best fossil localities in Crawford county, which are, among many others, principally these:

The ravines of Hayfield township, right bank of Cussewago creek; the ravines of Mead and E. Fairfield townships, left bank of French creek; and the banks of the Shenango at Jamestown, where the Gibson well starts at the top of the shales. It is frequently well-exposed in the common road cuttings of Richmond, Randolph, Woodcock, Vernon, Sadsbury, Summit, and Summit Hill townships.

* Here also it is darker and even some thin layers bituminous, which goes to support Prof. Orton's identification of it with Prof. Andrews' *Waverly Black Slate* of S. E. Ohio.

Chapter X.

Oil Lake Group.
Berea Grit of Ohio.
Pithole Grit of Venango.
Pocono Sandstone No. X, in part.

This group is composed of the *Corry* and *Cussewago sandstones* and the included *Cussewago limestone* and *shale.*

In the Beaver Falls well,* Beaver county, it is *recorded* as one solid pebbly sandsone 124′ thick.

In a well 3 miles north from the last† it is *recorded* pebbly throughout 102′.

In the Sharon well,‡ Mercer county, 30 miles further north, it is *recorded* as "white sharp sandstone, 75′.

In the Gibson well at Jamestown, on the Mercer-Crawford county line, 18 miles further north,§ the record gives 30′ fine blue sand, 65′ blue slate, ?′ coarse light colored sand =100′+.

At Oil Creek Lake, Crawford county, 38 miles further northeast, my section makes the whole thickness 130′. (See Fig. 11 page 75, above.)

At Tidioute, Warren county, 22 miles further east southeast, my section, Fig. 10, makes sandstone predominate through about 75′.

At Cleveland, in Ohio, 65 miles due west of Jamestown, Dr. Newberry's section‖ would make its thickness 103′+, if my identifications as given below prove correct. (See Fig. 11*b*, page 82, above.)

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*See Fig. 9, p. 73.
†See Report QQ, Fig. 17, p. 257.
‡See Fig. 8, p. 73.
§Report QQQ. p. 201, Fig. 118.
‖Geol. Ohio, Vol. I, p. 197.

BEREA GRIT [CORRY S.?]	exposed for 30′	
Red Shale, ...	38½′	103′
Blue Shale, ...	15′	
Blue Sandstone,* [CUSSEWAGO S?]	20′	
Cleveland Shale, black, ...		55′
Erie Shale to the level of the lake, ...		132′

In Ashland county, Ohio, 50 miles southwest of Cleveland, Mr. Read's section† exhibits beneath 270′ of Olive (*Cuyahoga*) shales, a (*Waverly*) conglomerate, 130′, which I interpret as representing my Oil Lake group. (*See Fig. 11c*, page 82, above.)

In Richland county, Ohio, which adjoins Ashland, Mr. Read's section,‡ makes this (Waverly) conglomerate 100′ to 190′ thick; beneath it "Argillaceous and sand shales, sometimes bituminous," 65′; beneath these "Shales with bands of flaggy sandstone," 235′; and then the "*Berea sandstone.*" (*See Fig. 11d.*)

It certainly looks as if the *Waverly Conglomerate* of these sections, the *Berea Grit* of Ohio, and my *Oil Lake group* in Crawford and Erie counties, occupied the same horizon; and if so, important consequences flow from the identification, as I shall show elsewhere.

Corry Sandstone.

(*Third Mountain Sand of Venango.*)

At all its numerous quarries, in Erie and Crawford counties, this rock presents similar features.

The two Corry quarries in the hilltop, one mile south and 300′ above the town, Colegrove's on the east side and Heath's on the west side of the road, are the most extensive in the region.—1740′ A. T.

Only 8′ of the rock has escaped erosion, and 4′ is so shattered that only the lower 4′ can be used.

Its hard yellowish-brown layers vary from 2″ to 1′, and contain a few ill-preserved fossils.

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* Quite massive at the East Cleveland quarries, but not so coarse as the *Cussewago* usually is in my district.

† Geol. Ohio, Vol. III, p. 523.

‡ Geol. Ohio, Vol. III, p. 316.

§ See also general section of Knox county, just south of Richland, Geol. Ohio, Vol. III, p. 335.

Elsewhere the Corry sandstone is usually 10′ or 15′ thick; I have nowhere seen it more than 30′.

A yellowish-white or buff-gray tint, and a compact fine-grained structure distinguish it from all the higher sandstones of the region.

In one or two places only I have found pebbles in it; and in one of these (in Concord, Erie county) pebbles of *jasper;* others dark and green; and small fragments of white quartz.

From its base large springs of water issue. It is the *fountain horizon* of the whole region, and when concealed may be thus found.

It rises from the bed of Oil creek near Titusville; is finely exposed along Pine creek; and identified along Thompson's run with the *Third Mountain Sand* of the Pleasantville (Venango) wells by Mr. Carll.

East of the county line, in Warren, on the road to Enterprise, it is finely exposed, 20′, massive, very *fossiliferous* near its base.*

North of Titusville, 2½ miles, just below Kerr's mill-dam, on Thompson's run, is a fine massive ledge of it; and from here up both sides of Oil creek it can be studied at Hydetown, Centreville, Riceville, and at Dobbins' quarry on Oil Lake.

Along French creek it shows itself in many ravines, and was once quarried in the bluff opposite Meadville.

On Cussewago creek, at Little's Corners, and on the next run, a mile above, considerable amount of stone has been taken out.

At Mr. Montgomery's extensive quarries in Summer Hill township, 2½ miles east of Conneautville, it is 10′ thick.

In Pine township, just north of Linesville, and also in the hills one mile east of the P. & E. railway station, are quarries from which much thin stone has been taken for wall work, &c.

Near the northwest corner of N. Shenango township its

* Here Mr. Hatch discovered and collected many fine specimens of *Syringothyris typa, Sperifera alta, Straparollus, Platyceras* (all very numerous), and others.

outcrop passes into Ohio and continues west as Dr. Newberry's *Berea Grit* outcrop.*

Its rise northward up Oil Creek valley shoots it over all Erie county except a few highest hills in the southern parts of Concord, Union and Le Bœuf.

Cussewago Limestone.

This rock greatly resembles the *Meadville Upper and Lower Limestones*, and shows the same glassy fracture, but is a better limestone

It underlies the *M. L. L.* by 120′ to 130′.

No fossils have been found in it in my district; but it may be represented in Warren county by the *Spirifer bed*, exposed in the railroad cut at Garland, 350′ under the *Sharon (Garland) conglomerate*, 1′ thick, and a mass of shells.

It was not described especially by Mr. Hodge in 1837, who only speaks of calcareous shales at this horizon of his Meadville section.

In Cussewago valley, it may be seen in several ravines.

It is finely exposed on Mr. Line's farm, 1½ m. below Little's corners; and at Bartholemew's quarry above Little's corners.

In Venango township, 1 m. west of Venango village on French creek, in Kleckner's ravine, it is 2′ thick. Blocks of it, strewn along the run, have made tolerably good lime.

Here it underlies the *top* of the *Corry sandstone* by 20′.

At the center of Concord township, (the only place in Erie county where exposures were seen on this geological horizon,) in D. Matterson's ravine, it is 1′ thick, and pure.

Here it underlies the *top* of the *Corry sandstone* by 25′. Its elevation is 1675′ A. T.

Cussewago Shales.

These separate the *Corry sandstone* above from the *Cussewago sandstone* below, and hold (near the top) the *Cussewago limestone;* corresponding thus to the calcareous shales in J. T. Hodge's Meadville section of 1837.

In some places the interval between the *Corry sandstone*

* The rock of the East Cleveland quarries looks very like the Corry rock.

and the *Cussewago sandstone* is filled, not with shales (with the limestone,) but with sandy flags (without the limestone;) and this accounts for the great thickness of the whole sandstone mass recorded by the wells of Mercer, Lawrence and Beaver counties.

The Bedford red shale formation of Ohio, should in my opinion belong here, but I have seen no red shale; although Mr. Hodge speaks of one 4′ "red and grey shale" bed in his Meadville section of 1837.*

The prevailing color of these shales is a bluish or ashen-grey.

Their average thickness is about 35′.

Cussewago Sandstone.

As it exhibits itself along the Cussewago valley this very peculiar rock (commonly of a buffish-brown color) is quite coarse, and in many places contains pebbles; but its sand grains cohere so loosely that the seemingly massive rock crumbles after a short exposure to a bed of sand.†

Manganese oxide (Wad) fills the crevices of the rock as exposed just west of Little's Corners,‡ and is the probable agent in blackening the top of the formation elsewhere.

At Meadville it lies in the hillsides 140′ above French creek.

From French creek to the Ohio line it can generally be traced by the sand along its disintegrated outcrop.

From French creek eastward, it seems to become harder

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* See for a discussion of the *Big Reds (Bedford?)* over his *First Oil Sand*, and the belt of country to which they are confined, Mr. Carll's third Report on the Oil Regions, 1880.

† Where it crops out on the road side. near Summit Station (P. & E. RR.) it can be shoveled like beach sand, and I should have mistaken it for Drift, but for shales and sandstone layers overlying it in place.

The story is told, that a Mr. W. had a quarry of the flinty *Sharpsville Lower* sandstone in his hill top; but, wishing to find some stone less costly for the cellar walls of his new house, he sought, found, stripped, and opened the outcrop of the *Cussewago sandstone* in the ravine below. The stone was apparently sound enough; the house was built. One winter's frosts sufficed to crumble the foundation, and the house fell.

‡ Here tunnels have been foolishly driven into the rock in search of *coal.*

and more compact; on Oil creek it is a very hard sandstone, 30′ thick.

Its color is not always buff-brown; occasionally it is a dark-green, or greenish-blue.

Fragments of wood are sometimes imbedded in it, as at Bartholomew's, in Hayfield.

Flat quartz pebbles are seen in it at many localities.

CHAPTER XI.

Riceville Shale.

Beneath the *Cussewago sandstone* and down to the First Oil sand of the *Venango group*, a distance of say 80′, comes in a series of very fossiliferous drab, bluish and gray, sandy shales, sometimes shaly sandstones.

On Oil creek this series is well exposed in the bluff just west of Riceville.

On French creek, right bank, southern edge of Hayfield, may be seen under the *Cussewago sandstone*, the following section:

Sandstone, flaggy,	12′
Blue sandy layer, containing many fossils: *Productus Boydii*, *Spirifera disjuncta*, a small *Orthoceras*, &c.,	1′
Concealed,	5′
Shales, blue sandy,	5′
Concealed,	5′
Sandstone, hard, flaggy, dark-bluish,	5′
Concealed,	12′
Sandstone flags, interstratified with bluish shales,	25′
Shales, pale blue,	5′

The fossils mentioned in the section above I have seen abundant at many places in the district, 15′ or more beneath the outcrop of the *Cussewago sandstone*. My identification of them as *Chemung forms* was confirmed by Mr. Whitfield, of the Museum of Natural History in New York.

If the Venango Oil Sand group, however, be either *Pocono* or *Catskill*, the presence of *Chemung* forms here only shows that they survived in this region long after the deposits of the Chemung age proper had ceased.

If any part of the Riceville shale represents the black *Cleveland shale* of the Ohio geology it shows no black layers in this Erie and Crawford region, except at one place, on Cussewago creek, in a ravine just south of Little's Cor-

ners. Here a few thin layers of *bituminous slate* scattere through 2′ or 3′ of shale, 25′ under the *Cussewago sandstor* (*i. e.* 50′ beneath its top line) were opened for cannel coa The chippings would burn, but were mostly ashes; and tl streaks never came together to form a bed.

If any part of the *Riceville shale* represents the *Bedfor shale* (which overlies the *Cleveland shale*) in Ohio, it show no *red* layers in this district of Pennsylvania. But a abundance of red beds overlie the First Oil Sand furthe southeast, south and southwest of Crawford county, a described by Mr. Carll in Report I.I.I., 1880.

Chapter XII.

Venango Oil Sand Group.

For an exhaustive description of this important and most interesting series of deposits the reader of this report is directed to the first and third Reports on the Oil Region of Venango, Butler, and Clarion counties.*

In these volumes, especially the latter, and on the plates of long sections in the atlas of illustrations accompanying it, may be seen amply displayed the three *Oil Sands*—their local sub-divisions into four, five, six, and sometimes seven—their separation from one another by shales of various color and consistency—the solidarity of the group, with a persistent thickness of 300′ more or less—the great, rapid local changes of character which each *Oil Sand* undergoes when followed by the observer from one group of oil wells to another, over a large area of Western Pennsylvania—the perfectly definite upper and lower limits of the group—the overlying "soft drilling measures"—and the underlying soft measures, persistent from the floor of the group downwards for at least a thousand feet, wherever pierced by deep wells.

The universal rise of the Palæozoic rock-deposits of Western Pennsylvania in the direction of the New York State line and Lake Erie brings the *Venango–Butler Oil Group* (sands and shales) to the surface for examination along an extensive belt of country stretching through McKean, Warren, Crawford, and Erie counties into Ohio.

The examination of this broad out-crop can teach us nothing more respecting the essential nature of the group, its average thickness and constitution, than we have already

* Reports of Progress I, 1875, I.I.I., 1880, by J. F. Carll.

learned from the myriads of wells bored through it wher it lies beneath the surface.*

But some radical changes of constitution take place i the *Venango Oil Group* towards its outcrop in Crawfor and Erie counties.

The most practically important of these changes was dis covered in the early years of the oil excitement, when sufficient number of bore-holes had been drilled northwes of Titusville to prove the *absence of the Oil Sands as oi bearing sands* in all the country between the Oil Bel which crosses lower Oil creek and Lake Erie. A coars sandstone is the only reservoir of free petroleum; and loose gravelly sandstone is the only kind of "Sand" fror which an oil producer expects a free flow of petroleum.†

The deposits of coarse, gravelly sand in the *Venang Group* are confined to two narrow belts of country; one commencing in southern Warren county, and stretchin through Venango into northern Butler; the other com mencing near Clarion, crossing the Allegheny river at Park er's, and ending in southern Butler county.‡

Between the two oil belts is a barren belt, along whicl the *Oil Sands* were deposited, but in the form of fine sanc and mud mixed; destitute of petroleum.

In the country southeast of the southern ("Lower") oil belt, the same conditions obtain, and trial wells failed.

So in the country northwest of the northern ("Upper" oil-belt, the sands were deposited, but in the form of com pact, fine-grained muddy flagstones; and in this form they make their appearance at their outcrops through Crawfor and Erie counties.

This statement must nevertheless be modified to meet a important exception; for, while it is true of the *First* an *Second Venango Oil Sands*, it is not true of the *Thir Venango Oil Sand*, if my identification of it with the *L*

*Some idea of the enormous mass of material at hand for the explanatio of this wonderful part of the Palæozoic column can be got by examining th volume of well-records published as Report I.I. in 1877.

† In large quantities at a time. The Bradford region furnishes vast quant ties, because *every* well yields a moderate quantity.

‡ See Map in Atlas to Report I.I.I. 1880.

Bœuf Conglomerate be correct. And this identification I account the most important discovery to which my survey of the district has given rise.

During the summer of 1879 I traced and studied the outcrops of the measures of the *Venango Group* over a large portion of Erie county, and along their exposures on both sides of French creek in Crawford county.

The measures underlying the *Venango Group* (*Chemung, Girard, Portage*) exposed for a maximum thickness of 1000′ I had the best possible opportunities for studying in the gorges of Conneaut, Elk, Walnut, Mill, Crowley's, Six Mile, Elliott's, Scott's, Twelve Mile, and Twenty Mile creeks, and in the many other and shorter ravines which open upon the lake shore; so that the question of the extension of the *Oil Sand members of the Venango Group* in an identifiable condition northwestward, as far as Lake Erie, and into the State of New York, may now be considered settled, as shown in this report.

While the *First and Second Oil Sands* fine into shales northward and westward, and cannot be clearly distinguished even in the Oil Creek Lake boring, nor in the Sharon and other wells of the Shenango, Mahoning, and Beaver rivers, the *Third Oil Sand* is struck in all the wells as a massive deposit, unmistakable in its position, and in its character; and it is possible to show that it (and the *Venango group* as a whole) extends through the State of Ohio as far as its central area in Knox and Ashland counties.

The *Venango Group* of rocks crop out over most of the surface of Erie county south of the great Divide, or high water shed; and the area thus occupied is shown by the light *red* color on the Geological Map.

The *thickness* of the group, averaged by Mr. Carll at 315′, I find varying in my district between 250′ and 350′.

Venango Upper Sand.
(*First Oil Sand.*)

This is shown on the generalized section, on the side of the Geological Map, as a sandstone 20′ thick. All that can

be said of it is, that sandy deposits occur at this horizo in other words sandy shales or flags occur among the fin muddy shales in the exposures of Erie county. But in case have I seen coarse or pebbly strata.

At Meadville 20′ to 25′ of sandstone flags rise out of t bed and run along the west bank of French creek, and a easily traceable by frequent exposures northward.

Two miles north of Saegertown they form a fine bluff, the east bank of French creek, where 20′ of coarse da brownish sandstone layers (1′ to 2′ thick) are cut throu by the railway.

In Erie county these flags lie high up near the hill top and are often grayish white.

At Anderson's quarry, 2 miles west of Edinboro', ove looking Conneautee lake, 1425′ A. T., they are bluish whit fine grained; sometimes a perfect mass of *fucoid casts smelling of petroleum;* and sometimes stained black. Only 5′ is quarried; and the bottom layer is coarse graine disintegrating on exposures.

A hill-top, 1 mile south of Union city, 1500′ A. T., an hill-tops near the northern line of Union township show flaggy sandstone probably referable to this horizon.

At Russell's quarry, just north of Corry, near the count line, a bluish white sandstone lies at 1640′ A. T., the sea and crevices of which *hold petroleum*, and parts of t quarry rock is stained with it.

Productella Boydii, *Aviculopecten suborbicularis*, *Pter nites*, *sp.?* and *Spirifer disjuncta* (all of them considere good Chemung types) I have collected from this horizon i my district.†

[* This supports my view of the indigenous origin of petroleum. See n report on the East Kentucky Oil Springs of Paint Fork of Sandy, Proc. Ame Philosophical Society. 1865, J. P. L.]

† In a visit to the Allegheny river exposures I saw the *First Oil Sand*, 1 above water level, at Tidioute, and double, as shown in my section there, Fi 10, p. 75 above. I think it is probably represented in the bluff, 2 miles abo Irvineton, right bank of the river, by a 25′ pebble rock, the top of which is 1 above water level, 1375 A. T. I think it is the quarry-rock at Warren, in whi Mr. Randall has found *Holoptychius*, *Coccosteus*, and a multitude of other *fi remains*; its top 240′ above the river, 1440′ A. T. I think it is represented the Great Bend section below Kinzua by the pebbly sandstone 240′ abo the river, and 375′ beneath the *Olean* (*Garland*, *Sharon*,) *conglomerate*.

Venango Upper Shale.

Pale blue shales, 90′ to 100′ thick, underlie the *Upper Sand* everywhere through Erie county.

Occasional thin sandy layers may be seen, and these sometimes thicken into sandy flags.

Fossil shells are quite abundant in most places where the shales appear, the prevailing forms being of Chemung type.

Venango Middle Sandstone.

(*Second Oil Sand.*)

This horizon makes little show in Erie county, being merely marked (everywhere) by a greater number of sandy shales or flagstone layers, in the mass of softer shales.

In many places in Erie county its presence is indicated by the shape of the ground, or it is actually exposed along streams; but nowhere have I found it a sandstone mass, or seen it exhibit a layer of pebbles.

At Harry Comer's quarry, however, in Washington township, 1355′ A. T. are exposed 12′ of bluish white sandstone (in 1′ and 2′ layers) the upper half shaley, the lower half quite solid, *smelling strongly of petroleum*, which floats off on the water of the springs which issue at the base. Underneath are seen blue shales.

In the Maynard's run bluffs, Amity township, the same flags crop out 125′ above the Le Boeuf Conglomerate (*Venango Lower Sandstone*) in the bed of the stream.

A red streak has been seen at several places in Erie county near this horizon.* One such place is just south of Doolittle's quarry, Amity township, where *red shale*, 15′ thick, shows in the roadside, 120′ above the top of the qnarry-rock, the *Venango Lower Sandstone*. Another is at Oil Creek Lake where the well record puts a *red bed* 166′

*In the Venango county oil region, at Tidioute on the Allegheny river, I recognized its fine exposure in massive layers of pebbly sandstone, its top 55′ above water level. Followed down the river it sinks to water level, and at Trunkeyville, 4 miles below Tidioute, its upper surface (10′ above railway grade) is *honeycombed* by numberless vertical stems of a *fucoid*, 6″ to 8″ long.

above what seems to be the same *Venango Lower San stone.**

Venango Lower Shales.

In the interval of from 100′ to 125′ between the *Venan Middle and Lower sandstones*, lie blue, gray and brow shales, *very fossiliferous.*

Sometimes the whole interval wears a dark colored aspec *Rhynchonella contracta*, *Streptorhynchus Chemunge sis*, *Leiorhynchus mesacostalis*, *Productella Boydii*, *Spir fera disjuncta*, and many other distinctively Chemung typ which I could not specifically identify are scattered throug the interval.

Two Spirifer beds are noticeable in some localities, fro 8″ to 12″ thick; and I was surprised to find in them a suf cient explanation of those soft, rotten, blackish lumps material, filled with casts of fossil shells, which may be see with scattered over the surface of the ground, and also mixe the *Northern Drift*, not only in Erie and Crawford count but as far south as the Ohio river. The rock when broke is as hard as flint; but of its old exposed surfaces nothin is left but the soft, earthy, darkened matrix, all the lime the fossils having been dissolved; the decomposition ofte penetrating to a depth of a foot. Many of the scattere blocks retain a core of the hard rock.

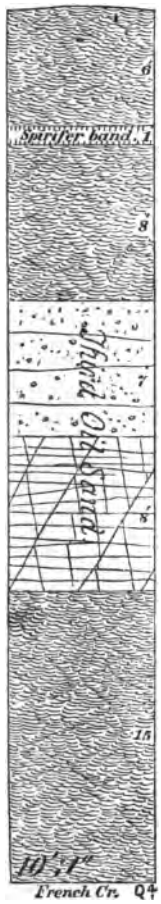
Venango Lower Sandstone.
(*LeBoeuf Conglomerate.*)
(*Panama Conglomerate.*)
(*Third Oil Sand.*)

Oil well borings between Titusville and Lake Erie enabl me to identify the famous "Third Sand" of the old oil r

*So also in the Beaver Falls well in Beaver county, the well record puts 1 of *red shale* at 116′ above what seems to be the same rock. I noticed at Col ham, 6 miles above Tidioute in Warren county, two massive sandstones (2 and 15′ thick, separated by 15′ of shales) occupying the *Venango Midd Sandstone horizon*, and the upper 25′ division was equally sub-divided b several feet of *red*, green, and variegated shales. But this coloring occurs so many horizons that it has no classical value except where it prevades great thickness of rocks, and persistently.

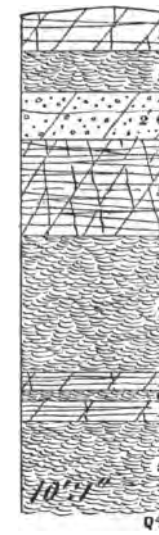
gion with the outcrop of a remarkable set of sand rocks capping the Great Divide overlooking Lake Erie, as shown by the northern edge of the red color on the geological map.

12.



13.

14.



Other outcrops of the same deposit descend French Creek valley, and LeBoeuf Creek valley to their junction ; encircle Black run and the head of Elk creek and enclose Conneaut creek for four miles above and below Spring P. O.

Its varying depths in the wells added to my hillside sections place it *750′ beneath the Sharon Conglomerate.**

I have traced this deposit across Erie county from the Ohio line to the New York State line.

Its exposures always show it *charged with petroleum*, even where it is a sand and not a gravel rock.

Its lower layers yield *excellent building stone* nearly everywhere.

It is the principal quarry rock of Erie county.

East of LeBœuf creek it is partly a coarse conglomerate; and with a peculiarity, for a great many *pebbles of metamorphic rocks* are found in it.

It rises to the surface in LeBœuf township at the mouth of LeBœuf creek, and here the *Carroll quarries* have been wrought for more than fifty years. (Fig. 12.)

Section at Carroll Quarries.

Shales,	6′		
Spirifer bed,	1′		
Shales,	8′		
PEBBLE ROCK,	7′	15′	1220′ A. T.
SANDSTONE, bluish white,	8′		1205′ A. T.
Shales, blue, to level of French creek,	15′		

The division into an upper gravel and a lower sand is realized at many other places in the county.

The upper gravel rock is a mere mass of quartz pebbles, *mostly flat*, or much broader and longer than thick; their smooth rounded edges showing long continued attrition. The quartz is mostly white; but jasper, green, and dark pebbles occur, and occasionally pieces of feldspar. *Fossil shells* are often seen in it, and fragments of *plants*.

The lower sandrock is tolerably fine-grained, of a peculiar bluish-gray or whitish color, everywhere throughout the county. Its layers are from 6″ to 2′ thick, splitting and dressing easily to a beautiful building-stone.

No constant division plane exists between the gravel-rock

* Mr. Carll's Pleasantville section, Fig. 12, Plate 4, Report I.I.I, shows the *bottom* of the S. C. at 1476′ A. T., and the *top* of the 3d Oil Sand at 767′ A. T. Difference, 709′. Add 37′ for thickness of 3d O. S. Difference between *bottom* of S. C. and *bottom* of 3d O. S., 746′.

and sand-rock; the gravel-rock thickening at the expense of, or thinning in favor of, the sand-layers.

Petroleum pervades both the gravel-rock and the sandstone layers; but there is more in the gravel-rock; and quarrymen say that they can occasionally collect a gallon of heavy oil at one time from the crevices at its base; and always enough to grease their wagon wheels.*

The top of the deposit is here at 1220′ A. T.

Doolittle's quarry is on the north branch of French creek, in Amity township, six miles northeast of the Carroll quarries; and the top of the exposure at 1340′ A. T.† The section is shown in Fig. 13.

Sandstone, hard, flinty, *fossiliferous*,	2′
PEBBLY LAYER,	3′
Sandstone, bluish-gray, reported,	15′

The top rock is almost a chert, and is *crowded with fossils*, the most abundant form being *Rhynchonella contracta*.

The layer beneath it is a mere mass of pebbles, cemented into a muddy-gray matrix of coarse sand. I noticed in it one piece of feldspar as large as my fist.

The quarried layers resemble those at the Carroll quarries, and smell strongly of *petroleum;* as does the pebble-rock.

Allen's quarry, 2½ miles from Doolittle's, shows the following section (Fig. 14):

Sandstone, cherty,			2′
Shale,			2′
PEBBLE ROCK,			2′ 6″
Sandstone, flaggy,			5′
Shale, blue,			7′
Quarry,	*Sandstone*,	1′ 0″	2′ 6″
	Shale, blue,	6″	
	Sandstone,	1′ 0″	
Shale, blue, visible for			5′

On *Mr. Smith's farm*, about 3 miles N. of Doolittle's, on the Amity north line, the following section shows the

* The stone is hauled to the P. & E. R. R. for shipment at Erie.

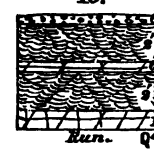
† Base of the quarry rock 1320′ A. T. Rate of dip towards the southwest, say *20′ per mile.*

deposit in the form of an immense gravel bed (pervaded with *petroleum*), thus (Fig. 15):

Shale,	visible, 3′
PEBBLE ROCK, (a mass of pebbles)	20′
Shale, blue, (with *fucoids*,)	5′

On *Mr. Bailey's land* in Venango township, near the New York State line, 2½ miles northeast from Smith's, this gravel-rock is seen thinned down to next to nothing, thus: (Fig. 16.)

16.



PEBBLE ROCK,	0′ 6″
Shales,	2′
Sandstone,	0′ 6″
Shales,	2′
Sandstone in the bed of the run,	1′

Elevation of base of deposit at Bailey's,	1425′ A. T
Elevation of base of deposit at Smith's,	1375′
Rate of fall towards the southwest, per mile,	20′
From Bailey's to Carroll's, distance 14 miles.*	
Rate of fall towards the southwest, per mile,	17′

West of French creek the pebble rock soon disappears from the outcrop exposures and only the characteristic blue flags remain.

Reynold's quarry, in Summit township, 1½ miles west of Jackson RR. station, 8 miles from Erie, has been worked a long time and here a small run exhibits the following exposures, (Fig. 17:)

Sandstone, *fucoidal,*	visible,	2′
Shale, blue,		8′
Sandstone, bluish-white (*quarried,*)		6′
Base of the rock,	*1510′ A. T.*	

From this westward the *fucoidal sandstone* becomes a new and constant feature, and sometimes there is to be seen a *fucoidal sandstone* also beneath the *quarry rock.*

Oil-springs issue from the fucoidal sandstone; and portions of the quarry rock are rejected because saturated with *petroleum.*

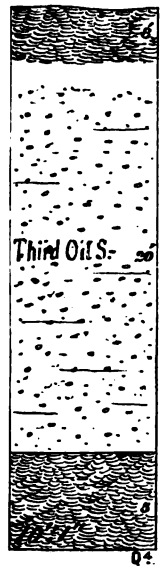
At *Middleboro'*, a run descending from the southeast shows the following section, (Fig. 18:)

* Air line, on the map.

Shale, blue,	visible, 5′
Sandstone, (fucoidal,)	7′
Shales and flags,	12′
Sandstone bluish-gray, (quarried,)	7′
Base of rock,	*1205′ A. T.**

The vertical *fucoidal stems* give the upper sandstone (as at Reynold's) a very rough aspect; but some of them lie horizontal. They occur also in the lower sandstone, which seems completely saturated with *petroleum*, for pools of it are to be seen all around the outcrop.

15.



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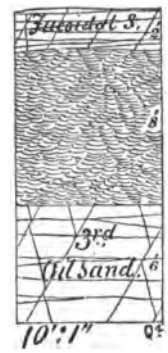


18.

Howard quarry at *Stone-quarry* village, in Franklin township, long and extensively worked, shows the following section, (Fig. 19):

Sandstone, hard, rough, *fucoidal,*	5′
Shales and slags,	10′
Sandstone, (*quarry rock,*)	4′
Shales,	10′
Sandstone,† hard, rough, *fucoidal,*	8′
Base of quarry rock,	*1150′ A. T.*

* Fall southwestward in 5 miles 95′; *rate 19′.*

† Probably existing in the previous sections but not exposed.

The quarry rock here is like that beneath the pebble rock at the Carroll and other quarries, and in many of its portions filled with *petroleum.*

Fossil shells are so abundant that portions of the rock are *calcareous* and as hard as flint. The species determined by Mr. Whitfield and Prof. Stevenson, of New York, are the following:

Productella, spec.
Chonetes Illinoisensis.
Streptorhynchus Chemungensis.
Rhynconella contracta, (*Stenochysma contractum,* Hall.)
Edmondia Burlingtonensis, White and Whitfield.
Grammysia Hannibalensis, Shumard.
Aviculopecten, spec.
Pteronites, spec.
Goniophora Aeola, Hall (and W.)*
Goniophora rigida, White and Whitfield.*
Platyceras paralium, W. and W.*
Orthoceras, spec.
Bellerophon, spec.

with the remark that "the fossils represent an horizon well down in the Chemung, so that if they are not Chemung, then there is no Chemung anywhere."

Fucoid casts also are numerous in the quarry rock. Many of those in the upper and lower sandstones have their stems vertical, and some of them seem to have a *horse-shoe shape,* or to enter the top of the rock somewhat like a staple driven into a piece of wood.

Shells filled with petroleum have been found in the quarry rock. Mr. Howard tells me that he has frequently found shells from which when broken open he has obtained a spoonfull or more of pure oil.

Goodman's quarry, north-east from Howard's quarry, is on a stream, up and down which the following section is seen, (Fig. 20.)

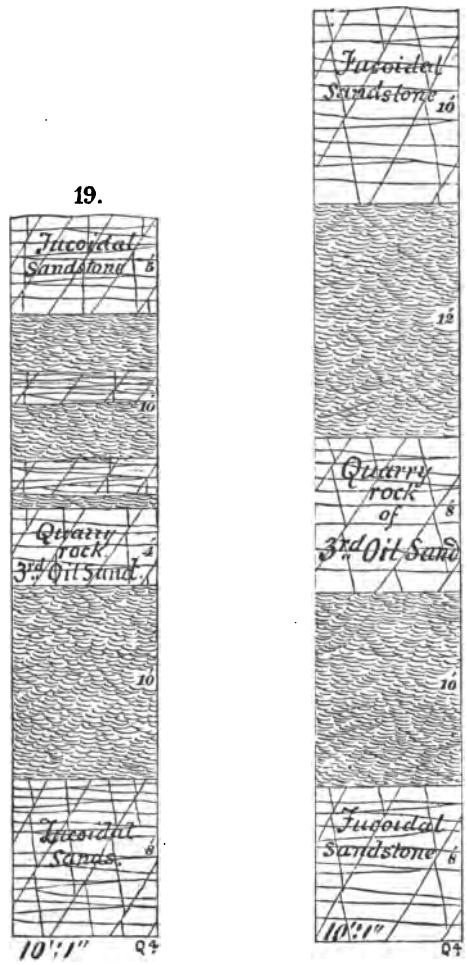
Sandstone, flinty, *fucoidal,*	10′	
Shales,	12′	
Sandstone, bluish gray, *quarried,*	8′	48′
Shales,	10′	
Sandstone, flinty, *fucoidal,*	8′	

* Burlington Group, Iowa.

The upper and lower fucoidal sandstones are exactly alike. In both the stems are vertical.

The quarry rock contains *petroleum.**

Near *Spring Village*, on Conneaut creek, is the only out-



crop of this rock which I have found exposed in Crawford county.

The various *elevations above tide* at the above places were

* For other localities in Erie county see Part II of this report, giving the detailed geology of each township.

not obtained by spirit leveling, but by Hicks' compensated field barometer, and the following results only approximate the absolute; yet they evidently obey a fixed *law of maximum dip more south than south-west*, thus:

	Miles.	*Fall.*	*Rate.*
Howard quarry to Spring village, . . .	.13	265′	20′ S. 32° W.
From Middleboro' quarry " "	.18	320′	18′ S. 46° W.
From Reynold's Quarry, " "	.23	425′	18½′ S. 34° W.
From " " to Stone quarry, . .	.11	160′	15½′ S. 66° W.
From Carroll Q. to Spring village, . . .	.22	320′	14½′ S. 70° W.
From Middleboro' Q. to Stone quarry, .	7	55′	8′ S. 78° W.

Eastward from Erie county, through the western part of the State of New York, I traced the outcrop of the *Venango Lower Sandstone* (*Third Oil Sand*, and *Le Beouf Conglomerate*) beyond Clymer, and identified it to my own satisfaction with the *Panama Conglomerate*, capping the highland south of Chautauqua lake.*

[* For Mr. Carll's views, see his Report I.I.I, 1880, pages 58 and 69. His description of the *Panama Conglomerate* occupies Chapter VI, pages 57 ff.

At Panama he determined its *elevation* (top 1671′ A. T.) by spirit leveling from Grant railroad station grade (1437′ A. T.) and its *thickness* as 69′. North of Blockville and west of the lake 50′+, (1660′ by barometer) A. T. At Ellory Center, east of the lake, fragments left on hill top, (1750′ A. T.)—William's quarry, 4 miles north of Panama, lower beds? (*base* 1660′ barom. A. T.)—Lewis' quarry, ½ mile west of last.—Chautauqua quarry, near Panama station, 5 miles west of Panama, quarry sandrock, underneath flat-pebble conglomerate, (*base* of quarry, barom. 1600′± A. T.—Bleaksley quarry, 3 miles south of Wattsburg, Erie county, shows 15′ of sand and gravel rock; but a bore hole reports 60′, (*base* 1340′) A. T.—Beaver run, west side, blocks. Doolittle quarry, 3 miles west of Bleaksley; (*base* 1330′ barom. A. T.) a well here yielding a little oil, 42′ to 130′ down —Quarries in Waterford, on McClelland's and Middleton's farms, old, reported by Hodge in 1837.—Moravian (or Carroll) quarry, near Le Bœuf, (*base* of pebble rock, 1220′ barom. A. T.)

Thus in 1875, Mr. Carll followed the *Panama Conglomerate* southwestward into Erie county 35 miles, identifying it with the *Le Bœuf Conglomerate* of the Carroll quarry; and in 1879 Prof. White followed the *Le Bœuf Conglomerate* from the Carroll quarry northeastward into New York, and identified it with the Panama Conglomerate. There can be no doubt of the identity; and the distance being 35 miles, and the difference of elevation (base 1750′ Chautauqua county; 1220′ at Le Bœuf) being 530′, the rate of fall is about 15′ per mile, about S.60°W.

Mr. Carll thinks that this rate would carry it beneath the surface beyond Le Bœuf, and therefore we find no more conglomerate in that direction. But Mr. White explains the fact satisfactorily, by showing that only the pebble rock layer dies out, but that the accompanying *fucoidal sandstones* keep on beyond Conneaut creek into Ohio.

We have seen above that the rate of fall continues about the same beyond

If the *Salamanca Conglomerate* be the same deposit, its great elevation at Salamanca (2190′ A. T.) is explained by the continuance of the same rate of dip for 40 miles eastward beyond Panama.

In Crawford county a number of bore holes have struck this *Venaugo Lower Sandstone* at various depths, and at some of these bore holes it contains more or less *petroleum;* (see Part II of this report.) In Mercer county I recognize it as the 30′ rock of the Sharon well (Fig. 8) and also in the Beaver Falls well (Fig. 9.)

Its frequent exhibitions of *petroleum* with the numerous *oil springs* along its outcrop through Erie county have been a fruitful source of vain hope and bootless exterprise to explorers. Little supposing that the *show* came from the outcrop itself and had nothing to do with the under rocks, explorers have drilled in almost every township to depths varying from 100′ to 1800′. Probably half a million of dollars has been thus wasted on dry holes, in Erie county, sunk through measures *underlying the Third Oil Sand* for which the drillers were seeking.

There is something ludicrously sad in imagining the sober rock looking down from a hillside day after day upon a derrick and a group of busy men, wondering what they were about, they all the while ignorant of its presence, and prob ing the earth to great depths to find it. A geologist who had studied the district thoroughly could have stopped

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Le Bœuf, viz: 22 miles to Spring village on the Conneaute, 1½′ per mile, S. 70° W., but that a rate of 20′ per mile is shown along a line of 13 miles S. 32° W.

Eastward from Chautauqua Mr. Carll in 1875 followed the outcrop of the *Panama* Conglomerate but a short way, and could not identify it with the *Salamanca Conglomerate* on account of the intervening 40 miles of comparatively low country (I.I.I, page 78.) I consider this good evidence of an original failure of the gravel deposit in that direction, and that the belt or stream of its deposit ran more northward and is now lost in air; its passing sideways (eastward) into sandstone, soft flags or shales, permitting easier erosion.

This, I suspect, will prove to be the explanation of the diappearance of the *Panama Conglomerate* southward in northern Warren county; thus *apparently* cutting its connection with that portion of it recognized in Southern Warren and Venango as the Third Oil Sand; just as Mr. White shows its massive pebbly character vanishing west of Le Bœuf in Erie county.

Thus the independent surveys of Mr. Carll and Prof. White are harmonized.—J. P. L.]

every such boring by merely pointing to the rock where it showed its face in the hillside, and tracing its line of outcrop on the county map.

The quantity of petroleum which the deposit originally held cannot now be estimated. For ages on ages the oil has been creeping through it towards its long lines of surface outcrop, seeping away from it in springs, and evaporating as gas. The whole deposit in Erie and Crawford counties seems to be now practically voided, as the dry holes show; but a residuum of oil, lowered in gravity and partly oxidized, still remains, as the quarries show enough in places to unfit the stone for being used as in building. *Petroleum* still oozes from the black stained walls of the Eagle hotel in Waterford.

The origin of petroleum receives an important explanation from these quarries.

My observations convince me that the theory of *distillation* from below is not only unproved, but unnecessary; and that the theory of *indeginous generation* is demonstrated on the very face of the exposures.

In other words the oil did not flow into the rock as distilled liquor into a condenser, or water into a reservoir; but was manufactured in the rock itself, and remained stored up where it was made.

The fossil forms of the organic beings out of which it was manufactured crowd the rock itself—shell-fish and seaweeds—as already described.

My opportunities for observing the facts have been unusually favorable in Erie county; and for that reason I may claim both for my facts and my conclusions careful consideration.

The conversion of the gelatinous tissue of Silurian coralline animals into *petroleum in situ* was observed long ago. The conversion of *fucoids* into *petroleum*, and of carboniferous *water-trees* into *cannel*, has been advocated by Lesquereux. But I have noticed what at first sight looks like *the conversion of the wood of air breathing trees into petroleum.*

At a quarry on Mr. Canty's land, just above the Carroll (Le Bœuf) quarry, the massive pebble-rock is completely

saturated with oil, while *fragments of trees stretch through it in all directions, like a fallen forest*, or rather like *a matted natural river raft.*

The woody fiber of these trees has not been replaced by mineral matter; but instead of that, the cavities in the rock, or rock-molds left by the decomposition of the trees, are now occupied by a soft, rotten, somewhat cellular substance with the strong odor, and the general appearance, in parts, of the residuum from evaporated and oxidized petroleum.

A thin film of coal is noticeable on some specimens; but in most cases the wood itself looks as if it had been converted into petroleum.

This can hardly be accepted as possible in the strict sense; but these Devonian plants may have had soft parts, with a structure analogous to that of the sea weeds, which would furnish the petroleum; and then, what of the woody fiber was left would be charged with it.

Such deposits of drifted land-plants may exist elsewhere in the oil measures may exist; but only in this one locality in Erie county did I see any notable quantity of them in this rock; which nevertheless is saturated with oil more or less everywhere.

I agree with Mr. Lesquereux therefore in referring the origin of the oil in the rock to *fucoids*, whose forms are visible by millions at all the exposures, with possibly one or two exceptions.*

Of course to the petroleum generated by the decomposition of sea-weeds *in situ*, must be added whatever petroleum was generated by the decomposition of the soft parts of mollusca *in situ*, the forms of which are also very numerous at some of the rock exposures.

If the oil (or gas) ascended from the deeper formations and was merely condensed into and held by the Oil-sand, surely some of the lower rocks ought to retain and exhibit traces of its passage upwards.

To test the possible fact, I made a special study of every stratum exposed beneath the Howard quarry. The lowest

(*See his memoir in the Transactions of the American Philosophical Society, Vol. XIII, p. 313, Philadelphia, 1866.)

bed of the *Venango Lower sandstone* here makes a cascade 60′ high, from the foot of which the stream rushes down towards Elk creek at the rate of 150′ per mile ; and along Elk creek are perfect exposures all the way to Lake Erie.

In 700′ of strata thus exposed to minute examination I could not detect a single bituminous lamina.

Not a trace of oil in any of the coarse Chemung flagstones.

The horizontality, the absence of faults, slides, fissures or crushes of any kind, and the multiplied alternations of impervious clay deposits, make the ascent of petroleum in the shape of gas a physical impossibility.

Beneath the 700′ thus exposed, 500′ more have been pierced by wells at the mouth of Elk creek, through nothing but the same gray shales, without a trace of bitumen.

Towards the New York State line 1000′ of layers beneath the *Venango Lower sandstone* are exposed, and no bituminous shales appear.

Some of the thin sand-layers of the *Portage group* are indeed more or less saturated with oil in many places ; but that the oil is indigenous to them also is plainly shown by its absence from similar layers above and below them.

CHAPTER XIII.

Middle Devonian Rocks.

(*Chemung*,* *Girard*, *Portage*, *No. VIII.*)

Only 325′ of typical *Chemung* strata underlie the *Venango group* along the New York State line, which considering the great thickness of the *Chemung* to the east and southeast, is I think an additional argument for including the *Venango group* in the same formation, I should therefore prefer to consider these 325′ of flag-stones as (palæontologically) *Lower Chemung.*

The 225′ of underlying *Girard* rocks yield no fossils except *fucoids*, and they may be considered (palæontologically) either as a Chemung group, or as a Portage group, or as a transition group, or as an independant intermediate group, according to circumstances outside of the district under review.

The 475′ of underlying *Portage* rocks exposed above water at the New York State line, are also *nonfossiliferous, except for fucoids.*

The distinction between the Girard and Portage beds is therefore one of mineral constitution, and is founded on the relative proportion of sandstone layers and shale layers, only.

Chemung.

Alternate groups of shale and sandstone; fossiliferous, especially in the upper half, with a thin *limestone layer* at the bottom; thickness, say 325′; outcrop along the Lake Erie slope. Their top layers are exposed also in the valley of French creek, as represented by the light tint of Vandyke brown upon the map.

* As I am disposed to look upon the *Venango group* as *Upper Chemung*, on account of its fossils, I should prefer to call these *Lower Chemung.* [My reasons for not agreeing to this are given in the Preface.—J. P. L.]

Generalized Section.

Shales, blue; with thin sandy layers,	25′
Spirifer bed,	1′
Sandstone, somewhat massive,	15′
Shales,	20′
Sandstone, flaggy,	15′
Sandstone, and *spirifer beds*,	12′
Shales, blue,	30′
Spirifer bed,	1′
Sandstone, flaggy,	20′
Shales, blue, *fossiliferous*,	50′
Sandstone, flaggy,	20′
Shale, blue,	3′
Sandstone, flaggy,	17′
Shale, blue, *fossiliferous*,	10′
Sandstone, flaggy,	10′
Shales and Sandstone, flaggy,	75′
Limestone, impure,	1′
Total thickness, say	325′

Some tolerably massive sandstone layers occur in the upper part of the series; but no pebbles—nothing coarser than sand grains—have been noticed.

Fossil forms (except *fucoids*) are wholly wanting at the base of the series; increase in number upwards; and become very abundant through the upper 175′; with numerous *spirifer beds*, two of which are specially mentioned in the section.

Rhynchonella contracta, *Leiorhynchus Newberryi*, *Spirifer disjuncta*, *Spirifer mesocostalis? Productella hirsuta*, *Productella lachrymosa? Productella Boydii*, are the common forms. *Atrypa hystrix* and many other genuine Chemung types occur.

Girard Shale.

A succession of ashen-gray and bluish shales, with only now and then a thin sandy stratum; no fossils except *fucoids;* thickness, say 225′; tinted a darker Vandyke brown upon the map; forms the Drift-covered rock-surface of western Erie county facing the lake, and is finely exposed in every ravine which descends northward from the Great Divide; but especially along Elk creek, above Girard. Seen at a distance, its bluff-slopes look remarkably like the Bowlder clay of the Drift, and sometimes like vast banks of gray coal-ashes.

Its base, or lowest layer, is at lake-level at Raccoon creek, near the Ohio State line, and 475′ above lake-level at the New York State line.

I have never found a single fossil shell in it, at hundreds of exposures examined; but *fucoid casts* are very abundant.

Its thickness of 225′ was fixed by several direct vertical measurements, and if in the Oil Lake well-section (Fig. 11) the "266′ of shells" be *Chemung*, and the "262′ of soft slate" be *Girard*, their united thickness (528′) will nearly equal my 325′+225=550′. This argues against any rapid or considerable thickening for some distance towards middle Pennsylvania, where the thickness is so very great.

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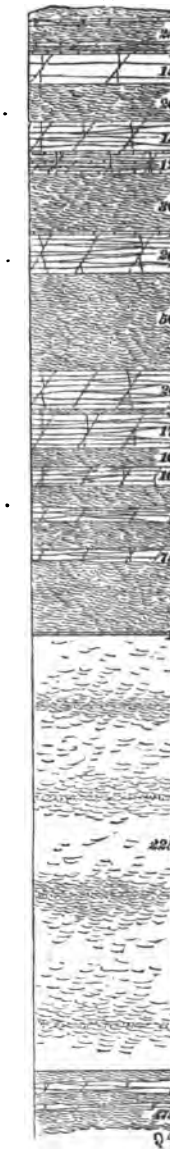

Portage flags.

A succession of alternate layers of grey shale, and thin layers of hard sandstone; no fossils except *fucoids;* thickness seen above water level at the New York State line, 475′.

The top layers rise from water-level within 2 miles of the Ohio State line, and slope up along the lake front to 475′ on the New York State line; and so more and more of the formation gets above the lake as described by Hall in 1844.

The layers of sandstone are usually 12″ or less in thickness; occasionally 2′.

Fucoids are characteristically abundant. Hall's vertical fucoids of the upper layers are not seen in Erie county, and the massive sandstones which carry them have evidently thinned and fined westward. But his *fucoides graphica*, casts of mud flowing over sand, and cone-in-conestructure occur in Erie county.

Petroleum and *gas* issue from some of the thin sand layers.

Collections of condensed gas undoubtedly exist; for quarrymen report the not infrequent occurrence of explosions, when they lift courses of the rock; and there seems no other explanation at hand for those sharp little ridges, or minute cracked anticlinals, seen in the shales along the streams. The gradual removal of the rock above has permitted the pressure beneath to exert itself forcibly and suddenly, upward along a short crack.

The gas and oil wells at Erie vary in depth from 450′ to 1200′. Deming's planing-mill well got gas at 453′ (*i. e.* in Portage layers 650± from the top down.) The average depth of gas flow is about 600′; the Fortuna well got a little oil at 585′; Jareki's two wells 700′ and 1200′; Brevillier's, 625′ (running for years; Conrad's brewery well, 600′. (See Report J, p. 33, Wrigley, 1875.)

Dr. Newberry identifies the New York *Portage* with the Ohio *Huron (Great Black) slate.*

Mr. M. C. Read's section of rocks in Knox and Ashland counties, Ohio, makes the interval from the top of the *Cuyahoga shale* or base of *Sharon Conglomerate* down to the top of the *Huron black slate* the same in middle Ohio as in Erie county, Pennsylvania, thus:

From lowest coal in Knox county, O. down to top of *Huron slate*, (Geol. Ohio, Vol. III, p. 335,) . . .		1265′
Sub-carboniferous and *Venango*, ... 750′		
Chemung flags, ... 325′	in Erie co.,	1300′
Girard shale, ... 225′		
From lowest coal in Ashland county, O., down to *Huron slate*, (Geol. O., Vol. III, p. 523,) .		1376′
From *Sharon coal* in Mercer county, Pa., down to *Portage flags*, I make, ...		1350′

With such general conformity over such an area is it possible that the whole *Erie shale* of the Ohio system can thin to a knife edge in the section in Huron county next north of Ashland—letting the *Waverly* down on to the *Huron?* Supposing my identification of the Ashland *Waverly conglomerate* with my *Oil Lake group* to stand good, the Ashland *Erie group* is 900′ thick. Can all this be lost in crossing one county line?

CRAWFORD AND ERIE.

PART II.

Detailed Geology of the Several Townships.

1. Wayne, in Crawford County.

This township is situated on the Venango county line, and is drained by Little Sugar creek.

Across its southwestern corner flows French creek; across its northeastern corner Sugar creek.

Sugar lake lies 2 miles from the county line, in a Drift-filled valley, as described in Part I. At Mr. Allen's, two miles above the lake, an oil well passed through 80′ of Drift below the level of the creek before striking any solid rock.

The height of the lake above tide is between 1275′ and 1280′, as determined with Aneroid Barometer, carefully checked at three different times.

Mr. G. W. Long, who has lived on its banks for 65 years, tells me that 43 years ago he took soundings in various parts of the lake, and found the average depth, at some distance off shore, to be 30′ to 32′; but now he says the depth is only 16′ to 18′. Its pure, cold water formerly contained a great many trout, as well as large quantities of black bass, perch, and sunfish, but owing to continual fishing, very few of any kind remain. Artificial hatching would probably prove successful, since numerous large springs around it, at 20′ to 50′ above its level, would serve that purpose very well.

The general surface of Wayne township is quite rough, since, in most cases, the streams have carved their channels down through the massive rocks at the base of No. XII;

while many of the hills in its southeastern portion rise high enough topographically as well as geologically to take in the whole of the *Conglomerate series*, and possibly a small portion of the *Lower Productive Coal column.* Hence this township contains the highest rocks known anywhere in Crawford county. It is, therefore, one of the few in which *coal* occurs.

The Wentworth well was drilled near the southern line of the township, about 2½ miles south from Sugar lake. The following record is furnished to Mr. Carll by Mr. Thos. T. Hall:

Wentworth bore-hole. Fig. 22.

1.	"Clay and Gravel,"	46′ to	46′
2.	"Slate,"	8′ to	54′
3.	"Coal, { 1. Coal, 1′ 2. Slate, 5′ 3. Coal, 2′ }"	8′ to	62′
4.	"Slate,"	6′ to	68′
5.	"Sandstone,"	32′ to	100
6.	"Bluff S. S.,"	100′ to	200′
7.	" ? ",	100′ to	300′
8.	"Mt. Sand,"	100′ to	400′
9.	" ? ",	306′ to	706′
10.	"1st S. S.,"	15′ to	721′
11.	" ? ",	231′ to	952′
12.	"2d Sand (some oil),"	10′ to	962′
13.	"Slate,"	15′ to	977′
14.	"3d Sand (better oil show),"	2′ to	979′
15.	"Slate, soapstone, &c., nothing hard to drill through to bottom of hole (at 1100),"	121′ to	1100′

From Mr. Wentworth, who worked at the drill hole, I learned that from No. 10, several gallons of oil were obtained with much gas, and that the "shells" in connection with No. 14 were perfectly saturated with oil, though the rock was too fine in texture to hold any considerable quantity. It seems to me that this No. 10 stratum is 125′ too low for the First Oil Sand.

As the drillers had reported a large bed of coal, a coal operator was employed to drill a hole about 8 rods south from the oil well, and reported as in Fig. 23, (transferred to the oil well section Fig. 22,) and the work was abandoned.

Liberty furnace, about one mile west from this just over

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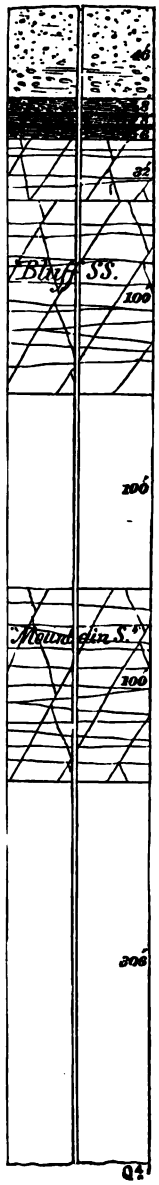

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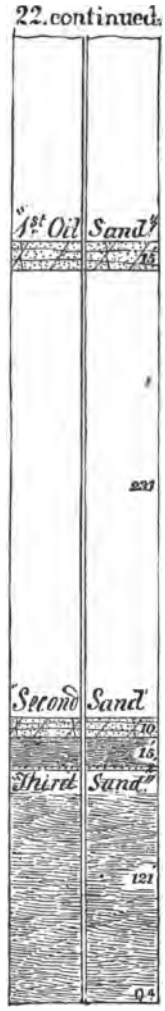

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the Venango line, used native ores and went out of blast 35 years ago. It was located near the head of one branch of Deckard's run, on the McDaniel property, where the coal of Wentworth's bore hole was mined, and the following section can be got along the run, (Fig. 24):

Liberty Furnace Section.

1. Concealed,					50′
2. *Iron ore*,					1′
3. Shales, massive SS.,					20′
4. Coal,	1. Coal,	10″		Sharon,	6′ 10″
	2. Cannel slate,	4′ 6″			
	3. Coal,	1′ 6″			
5. Shales,					3′
6. Massive SS. in cliffs,					20′
7. Grayish shales,					15′
8. Massive SS. in cliffs,					25′
9. Shales, brown and sandy,					20′
10. Sandstone, seen,					10′
11. Concealed with occasional outcrops of massive SS.,					87′
12. Meadville Upper limestone,					2′

Iron ore (No. 2,) was here the principal source of supply for Liberty furnace; it is a carbonate ore and quite rich.

Sharon coal? (No. 4)—This identification is doubtful, because it comes so far (180′) above the Meadville Upper limestone.

Its upper and lower benches are of very fair quality, and were mined for the old furnace. The middle bench is an impure variety of *cannel*, and Mr. McDaniel states that it burns tolerably well if the purer portions only are selected. It is finely laminated in some portions; and again it breaks with a conchoidal fracture.

Lingula.—In the laminated portions I saw many specimens of a *Lingula* which I could not distinguish from *L. melia*, Meek, of the Cuyahaga shale. The shells have left nothing on the layers of cannel except a shining film marking with great distinctness the outline of the shell.

Sandstones Nos. 6 and 8 are both quite heavily bedded, and each makes a line of cliffs along the hillsides. No. 8 may possibly represent the *Sharon Conglomerate*, unless the report of an old miner be true, who tells that once (40 or 50 years ago) after a flood had stripped away all the dé-

bris and left the strata completely exposed, he saw a bed of coal 4′ thick just below our No. 10 in the interval now concealed. If this were true it would represent the *Sharon coal*, while Nos. 6–10 would represent the Connoquenessing SS.; but this would place the Sharon coal only 80′ above the *Upper Meadville limestone;* while the least interval between the two elsewhere seen in Crawford is 135′, so that the "report" is to be received with much incredulity.

Meadville Upper limestone No. 12 was once mined on the land of Mr. Shuey, one half mile above Deckard P. O., and used as a flux at the Liberty furnace. It is 2′ thick but quite silicious, so that it had to be mixed with the Lower Mercer limestone from Utica. The rock cannot now be seen in bed, but Mr. Shuey showed me the bench where he had quarried it during the time the furnace was in blast. He also burned it and reports that it made very beautiful lime, being exceedingly white.

Hoffman's oil well boring.—Just above where the limestone was quarried, and near the county line, a well was once drilled on the land of M. Hoffman. It commenced at an elevation of 1290′ above tide, about at the horizon of the limestone, and was drilled to a depth of 725 feet; no record was preserved except in the memory of Mr. Hoffman—"63′ of drive pipe was used before rock was struck. First show of oil was between 300′ and 400′; last sand struck at 650′ (10′ thick) with strong show of gas and oil; sand good, and oil green." This would be the *3d oil sand horizon*, if it be the base of the *Sharon Conglomerate* that is seen 100′ above the mouth of the well.

A heavy vein of water was struck in the drift deposit at 60′, and it still flows from the casing in a large stream.

An abandoned oil boring was drilled on the farm of Mr. Tingley just south from Deckard's P. O. to a depth of 700′ commencing at 1350′ above tide, and reported to have a very good "show of oil."

Feldmiller's oil borings.—A short distance above the mouth of Deckard's run, on the Little Sugar Creek bottoms, two wells were drilled on Mr. Feldmiller's land each 600′; both gave some show, but only produced gas and water.

Grass run.—One mile north from the mouth of Deckard's run, a small stream called Grass run puts into Little Sugar Creek and along the lower portion of its course the *Shenango sandstone* is seen in great development. Where the road crosses Grass run, one mile above its mouth, the stream has cut down just to the top of the rock. After rushing along on its top for 100 yards, it leaps into a deep and narrow chasm with an almost perpendicular fall of 35 feet. A short distance below the falls I obtained the following carefully leveled section, (Fig. 25):

1. *Shenango sandstone* in cliffs, ... 30′
2. Shales, blue, very soft and argillaceous, ... 36′ 6″
3. *Meadville Upper limestone*, ... 2′
4. Shale and flaggy sandstone, ... visible 5′
5. Concealed to level of Sugar creek, ... 125′

The Shenango sandstone extends along each side of the gorge in a long line of unbroken cliffs, getting higher and higher above the stream as it rapidly descends through the soft shales of the Cuyahoga formation. It is very massive and contains immense numbers of *iron balls*, varying in diameter from 1 to 6 inches. The rock is coarse, grayish-brown in color and contains many *fish remains*, chiefly unrecognizable fragments of scales and bones. The base of the stratum comes here 1315′ above tide as determined by three carefully checked barometical measurements.

The blue shale has been scooped out perpendicularly for several feet under the cascade.

The *Meadville Upper Limestone* is finely exposed for several rods along the gorge; very fossiliferous; filled with *commingled fish-scales*, *teeth*, *spines* and *bones;* and many shells of *Discina*, *Spirifera*, *Productus*, and *Rhynchonella?* The stratum is quite silicious and in the *fish layer* is a conglomerate mass of smoothly worn and mostly flat pieces of shale and fine-grained sandstone. Top, 1280′ A. T.

The rocks beneath, partially exposed, appear to consist mostly of flaggy sandstone with alternations of shale.

Pine Knoll is a very high knob nearly a mile northwest from the last locality. Rising far above any of the surrounding hills, its crest, covered with a dense growth of tall pines, makes a conspicuous object in the general landscape.

The Sharon (?) coal bed has been mined near the summit of the knob for 50 years or more; at one of the old openings I saw the following succession:

Conglomerate sandstone, massive,	visible, 15′
Shale grayish sandy,	10′
Coal,	1′

The sandstone is quite coarse and often conglomeratic; easily disintegrates and seems in all the exposures to be all broken up, probably by the Glacial ice; since the top of the knob is only about 50′ above the coal.

The coal bed although so thin, has been opened in several places around the knob, and a considerable amount of coal has been taken from it, since no other bed is accessible for a distance of many miles. It is an impure *block coal* and may represent either the *Sharon* or the *Quakertown*.

Its elevation is 1475′ A. T. and (1475—1280′) 195′ above the *Meadville Upper Limestone*, on Grass run, ¾ of a mile south. But as there is a slight rise here to the northwest, the true interval is probably not far from 175′; which agrees quite closely with that found between the sandstone and coal at Liberty Furnace. Mr. J. T. Hodge called it the *Sharon coal* in 1838, and it may possibly be that bed; but the interval between it and the limestone is only from 100′ to 135′ along the western line of the county; but the intervening measures may thicken eastward.

Just opposite Pine Knoll, on the west side of Little Sugar creek, a very high ridge of land on the property of Mr. Slingluff catches a small area of the coal, but it has never been mined there to any extent.

Yoset's coal.—On the summit one and a half miles northeast from Pine Knoll Mr. Yoset dug a well, and found 8″ of *slaty coal*, having the same *block-like* appearance as that on Pine Knoll. Well mouth, 1525′ A. T.; coal bed, 1505′ A. T.

Messerell saw-mill section:—On the land of Mr. Messerall, near the northern line of Wayne Tp., a small stream puts into Big Sugar creek, and at the saw-mill the following succession occurs: (Fig. 27.)

1. *Shenango sandstone*, ... visible, 20′
2. Shales and concealed, ... 35′
3. *Meadville Upper Limestone*, ... 2
4. Concealed to level of Creek, ... 30

The sandstone is here very massive, and forms a bold cliff along the stream; a cascade 20′ high affords excellent water power at the saw mill.

The limestone was once quarried and burned by Mr. Messerall who reports it as making a very fine white lime, though it had to be calcined quite long before it would slack well. The horizon of the limestone was concealed by débris when I visited the locality, but Mr. Messerall showed me where he had dug it out of the bank and also some loose pieces lying along the stream.

The base of the sandstone in the section lies 75′ above the level of Sugar lake, 2½ miles to the southeast. There is a considerable dip in that direction, so that at the lake the sandstone is only 30′above the water, as is shown by a row of immense blocks of the sandstone, none being seen on the slope above.

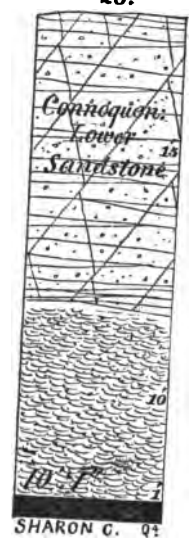
A line of large springs also issue from a little below the horizon of the sandstone blocks. Such springs are nearly always found at its base.

About one and a half miles south of the lake a long high ridge of land rises 400′ above the lake. This is high enough to catch the *ferriferous limestone*, unless the drift which covers up everything out of sight on the ridge be very deep.

Barometric elevations in Wayne township.

Sugar lake, ...	(above tide,)	1280′
Crossing of road south from the lake, ...	"	1275′
Cross roads at J. Lepley's, ...	"	1670′
" " Drake's School House, ...	"	1500′
Deckard P. O., ...	"	1240′
Forks of road at P. Hollbaugh's, ...	"	1335′
Cross roads at R. Heath's, ...	"	1370′
School house east from W. Roberts, ...	"	1140′
Cross roads at W. Watson's, ...	"	1290′
" " J. Lubold's School House, ...	"	1440′
Bresler's Flouring Mill, on Sugar creek, ...	"	1090′
W. L. Lubold's, ...	"	1305′
Crossing of Sugar creek at R. Kaster's, ...	"	1140′

26.



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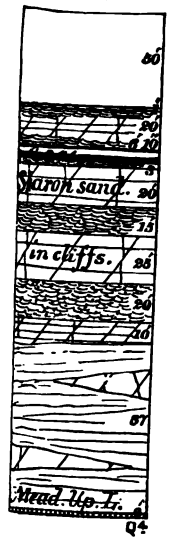

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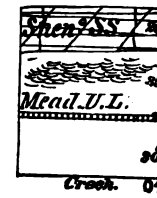

9 Q⁴.

Forks near S. Houtz's,	"	1205′
" next above,	"	1210′
Forks at J. D. Frost's,	"	1330′
" W. McElroy's,	"	1350′
" D. Dupont's,	"	1350′
" A. Pegan's,	"	1370′
" W. Record's,	"	1290′
Crossing of Grass run,	"	1345′
Cross roads at Jannesat's School House,	"	1440′
Crossing of Grass run east of School House,	"	1430′
Cross roads near G. Long's,	"	1520′
George McDaniel's School House,	"	1340′
Forks next east,	"	1320′
" next south east,	"	1310′
Level of Big Sugar creek on John Allen's estate (road crossing,)	"	1290′
Forks at J. Boyd's,	"	1300′
" near W. McDill's School House,	"	1475′

2. *East Fairfield, Crawford county.*

This township stretches along the east bank of French creek, south of Mead.

Along its central portion parallel with French creek, extends a long high ridge, high enough in some places to hold the *Sharon coal.* The descent to French creek westward is rapid. East of it is the valley of Little Sugar creek, which curves through Wayne township and enters French creek at Cochranton, near the southern corner.

Sharon coal bed.—A small patch of this bed remains on the ridge near the northern line, about a mile east of French creek, on the land of Mr. A. H. Byhm.

In the summer of 1878, Messrs. Lewis and Oliphant, of Pardoe, explored this deposit, because it was reported that 4 feet of coal had been drilled through on the opposite side of French creek, 2 miles distant, and at a much lower level. Four or five holes were drilled on Byhm's hill, and some coal was found in each. Then a shaft was sunk 55′ through drift; but the coal when reached was so broken and mixed with drift deposits that its original thickness and character could not be told. In none of the holes was anything but drift found over the coal—1510′; coal bed 1445′ A. T.

Just south from Mr. Byhm's, a small stream starting on the high divide flows west into French creek, and exposes a very good section for a portion of the distance; and descending it from the Byhm shaft, the following succession occurs, (Fig. 28):

Byhm's run section.

Drift in shaft,	55′
Sharon? Coal,	?
Concealed,	100′
Shenango Sandstone, massive,	25′
Concealed with occasional exposures of flaggy sandstone,	80′
Sharpsville Sandstone, flaggy,	40′
Meadville Lower Limestone,	1′
Sandstone, flaggy, and concealed,	75′
Orangeville Shales, bluish,	2′
Concealed to level of French creek,	80′

The *Shenanago sandstone* here forms a conspicuous cliff around the head of the ravine, and is the same coarse brownish yellow rock filled with *iron balls* that always occurs at this horizon in Crawford county. Mr. Lewis drilled 20′ into it for coal but abandoned it.

The *Sharpsville sandstone* makes very steep slopes along the stream, and many of its layers are very compact.

The *Meadville Lower Limestone* is seen wedged in between layers of sandstone; it is quite siliceous and breaks with the glassy peculiar fracture described on page 84.

Of the *Orangeville shales* only the lowest 2′ are seen; the upper 60′ is here concealed.

About ¾ of a mile above Shaw's Landing, a very good section of the measures below the *Shenango Sandstone* is obtained in descending a ravine on the land of Mr. Adam Shreck, as follows: (Fig. 29.)

Adam Schreck's Section.

Shenango Sandstone,	visible,	10′
Concealed,		5′
Shales, bluish, sandy,		20′
Sandstone, flaggy,		5′
Meadville Upper Limestone,		1′ 6″
Concealed,		10′
Sandstone flaggy, and sandy shales,		30
Shales, slaty,		5′
Sharpsville Upper Sandstone, flaggy,		40′

Meadville Lower Limestone,	1′
Sharpsville Lower Sandstone,	15′
Orangeville blue shales with *Lingulae* and *Discinae*,	55′
Concealed to level of French creek,	110′

The *Upper Limestone* is a perfect mass of smoothly rounded and mostly flat pebbles of shale; nodules of iron; and fragments of *fishes*, including scales, teeth and bones.

The *Lower Limestone* is here found in the center of a quite hard and massive sandstone, from which its weathered surface cannot be distinguished; but a fresh fracture reveals its limy character at a glance.

In the *Orangeville shale* many specimens of *Lingula melia* and *Discina pleuritis* were seen in it, at this locality. The shale is quite fine-grained and has in it a very few thin layers of grit.

Railroad deep cut section.—One mile below Shaw's Landing, and just above the bridge across French creek, the following rocks are seen in a deep cutting along the A. & G. W. R. R: (Fig. 30.)

Corry Sandstone,	10′
Shales, blue,	25′
Concealed,	25′
To level of French creek,	1055′ A. T.

The *Corry Sandstone* comes in layers here 1′ to 2½′ thick, and is a tolerably coarse, brownish-colored rock. Its top lies about 180′ lower than the base of the *Shenango Sandstone.*

The fine-grained, bluish-gray shales contain three or four layers of lean siliceous iron ore 2 to 3 inches thick.

Sharon Conglomerate?—As we ascend the hill-road to the east, just below this, the outcrop of a massive sandstone is seen at 1340′ A. T. up to 1370′ at the summit. The surface is strewn with blocks of pebbly sandstone.

On the ridge road near Mr. J. F. Powell's, an old valley of erosion is seen stretching across from Little Sugar creek to French creek, with a general level of 1240′ A. T. Its side slopes are 100′ to 150′ high.* The lower part of the present valley of Sugar creek has the appearance of being

* See Part I, p. 36.

a recent cut, for its sides are very steep, and often show the horizontal strata cropping out free from Drift.

30.

Barometric Elevations in E. Fairfield.

Forks at R. Cochran's, ...	(above tide),	1100′
" J. Klinger's, ...	"	1270′
Cross-roads at Lafferty's school-house, ...	"	1385′
Forks at T. F. Powell's, ...	"	1340′
" H. Heath's, ...	"	1160′
Lane at James Marley's, ...	"	1175′
Road at J. F. Powell's, ...	"	1250′
" D. McFate's, ...	"	1340′
" school-house, next north,	"	1360′
Cross-roads at R. McFarland's,	"	1390′
Crossing of run at J. Stonebrooks',	"	1305′
Cross-roads at J. Stoddard's, . . .	"	1230′
" A. S. Beatty's, . . .	"	1110′
Forks at E. E. Smith's, ...	"	1445′
" L. Byhm's, ...	"	1510′
" F. Fryermuth's, ...	"	1410′
Cross-roads at D. Verain's, . .	"	1250′
Crossing of Little Sugar creek, next east, ...	"	1175′
J. Champage's, forks of road, . . .	"	1200′
Crossing of Sugar creek at G. Mill,	"	1160′
Forks at H. Stitzer's, ...	"	1180′
" R. McFate's, ...	"	1200′

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3. Union, in Crawford County.

This township occupies the triangular area between French creek and Conneaut Lake creek. Small streams descend from its central high land both ways. Its northern line follows a low valley, through which the A. & G. W. R. R. passes, from French creek two miles below Meadville, over to Conneaut Lake creek at Geneva. Some of the elevated land rises high enough to take in the *Sharon Coal.*

On the land of Mr. Juo. Klipple the *Sharon Coal* out-

crop is seen in a ditch near the summit of the hill. There is no covering above it, however, except *Drift*, and the coal has been so very badly broken up that it was found impossible to mine it with any success. But Mr. Pierson, of Meadville, once succeeded in getting several wagon loads.

The outcrop of the *Sharon Coal* is seen on the bluff just west from French creek, where the following section was made (Fig. 31):

Section at J. Klipple's.

Drift,	25′
Sharon Coal bed,	2′–3′
Concealed, but containing the Massive *Shenango S. S.* at base, 5 feet of which can be seen,	95′
Shales, bluish and Sandstone, *fossiliferous*, flaggy,	40′
Meadville Upper Limestone,	2′
Flaggy S. S. and shales, with *fucoids*,	8′
Concealed,	25′
Flaggy S. S., containing many *fucoids*,	15′
Concealed,	40′
Flaggy S. S.,	10′
Concealed to level of French creek,	135′

Here we get an interval of 135′ between the *Sharon Coal* and the *Meadville Upper Limestone;* but the *Sharon Conglomerate* seems to have a very poor development in this section, since it does not make any show and this probably renders the interval less than it would otherwise be.

The *Shenango sandstone*, the lowest 5′, of which only are visible, makes a steep bluff; many huge blocks of it lie scattered over the surface below, some of them pebbly.

The flaggy sandstones beneath it contain sub-carboniferous forms of *Spirifera* and *Allorisma*.

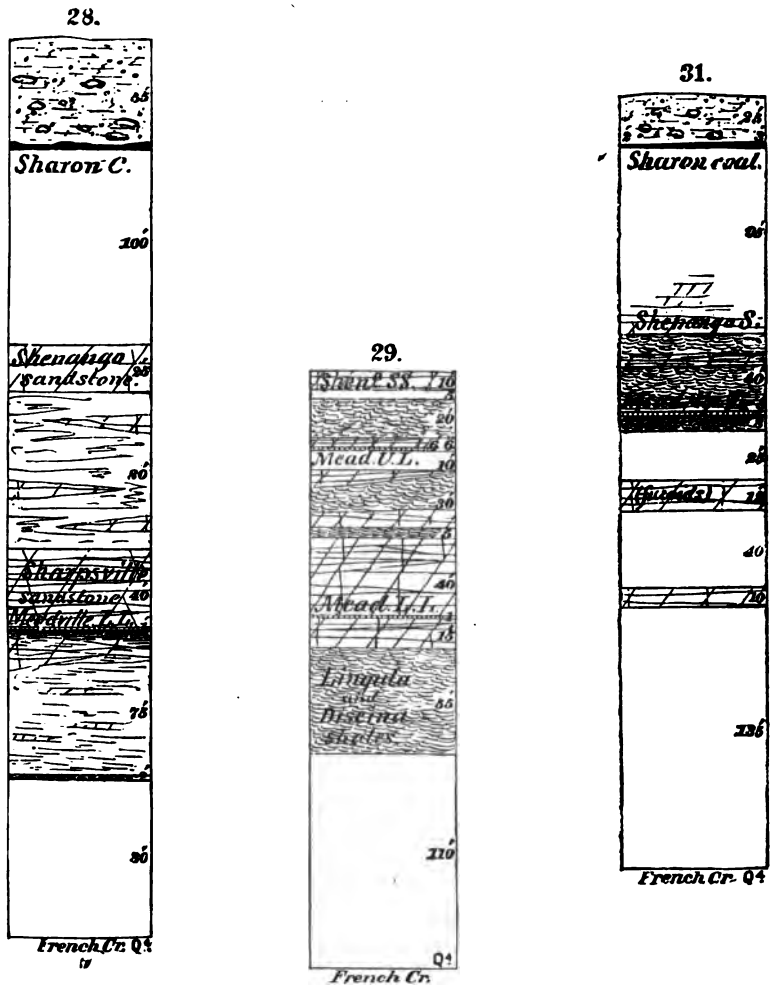
The *Meadville Upper Limestone* is here quite silicious, and breaks with its usual glassy fracture.

The flags under the limestone contain a great many cylindrical *fucoids*.

A bore hole was drilled by two men a short distance north from the line of section described above, commencing 75′ below the *coal*, and they reported 3½′ of coal, 50′ down.

Mr. Lewis of Pardoe offered to purchase if they would

allow him to put a hole down along side of theirs to test the coal; this they refused to do, and would only allow him to test within 10 rods south of their hole, at about the



same level, but no coal was found at 50′, and the deception was evident.

Berg's quarry. About one mile west from Mr. Huber's, a high ridge, on the land of Mr. Berg, has its top covered with massive blocks of white sandstone (*Sharon Conglom-*

erate or possibly *Lower Connoquenessing S. S.*) The rock has been quarried to some extent and makes an excellent building stone, although rather hard to work.

Descending from this, south, toward Conneaut Lake creek the following succession occurs: (Fig. 32.)

Berg's quarry section.

Concealed, and covered with white S.S. blocks,	100′
Shenango Sandstone,	20′
Concealed with an occasional outcrop of flaggy sandstone,	150′
Meadville Lower Limestone, (1155′ A. T.,)	1′
Sharpsville Lower Sandstone, flaggy,	10′
Concealed to level of Conneaut Lake creek,	90′

The *Shenango S. S.* is seen in large blocks scattered over the hill side; was formerly quarried quite extensively and used in the construction of the old Beaver canal feeder.

The *Meadville Lower Limestone,* seen along the road a few rods above where it crosses the old canal feeder, is very hard and flinty, and has sandstone above and below it which it outwardly resembles.

Barometric elevations in Union.

Township line, on road ½ mile west from French creek,	(above tide,)	1320′
Forks of road at J. Hank's,	"	1275′
Crossing of A. & G. W. R. R. near G. Reitzer's,	"	1090′
Forks at Bierly heirs,	"	1130′
" George Perkin's,	"	1175′
" S. A. Beer's,	"	1355′
Lane near Fred. Steins,	"	1405′
Road at Huber's School House,	"	1435′
" J. Bower's,	"	1435′
Forks at Adam Rungs,	"	1380′
Cross roads at F. Karn's,	"	1420′
Lane at O. Power's,	"	1370′
Cross roads at H. Power's,	"	1080′
Creek opposite,	"	1055′
Forks near Asa Smocks,	"	1105′
Forks near O. H. P. Herrington's,	"	1095′
Crossing of A. & G. W. R. R. next north,	"	1095′
Forks at J. Hannah's,	"	1240′
" C. Van Horn's,	"	1115′
Crossing Reitzer's run next north,	"	1075′

4. Fairfield, in Crawford County.

This township lies between French creek, Conneaut Lake creek, and the Mercer county line.

Along the county line the land is quite elevated, and many of the hills rise high enough to take in the *Homewood S. S.*

Near its southwest corner, at the county line, Mr. Bickerstaff once drilled and reported 3′ to 4′ of coal, at a depth of 80′. He also tried to open the bed at the outcrop, but found that the massive sandstone roof cut out the coal. The bed is that mined on the land of Mr. John Fulk, in Mercer county, one mile south, described in QQQ, page 205.

On the summit at Mr. Wm. Johnson's, a well was dug, and in it a coarse pebbly sandstone, partially decomposed, was struck at 7′ below the surface; this is most probably the representative of the *Homewood sandstone.*

On the land of Mr. Gourley, two miles west from Johnson's, and near the county line, a hole was drilled to a depth of 120′, testing for coal; the rock was struck at a depth of 20′. Somewhere between 80′ and 100′ Mr. Gourley says the drillers found something *black*, which they claimed as *coal*, but others thought it only *black slate.* One of the *Mercer coals* ought to have been found in this interval, since it is only ¾ of a mile north from Chateley's, in Mercer county, where the *Mercer Lower coal* was once mined (see QQQ, page 206. The surface at Gourley's is 1445′ A. T., nearly 100′ higher than Chatley's coal mine.

Just north from the cross-roads at J. H. Calvin's the outcrop of a massive sandstone, coarse and white, is seen at an elevation of 1465′ A. T. It is probably one of the *Connoquenessing sandstones.*

One mile north from this a great many sandstone blocks are seen scattered over the ground, and a ledge of the rock from which they were derived crops out near Mr. S. Hills, at 1390′ A. T.

One half mile further north the outcrop of the *Shenango sandstone* makes a steep bluff around the hills at 1290′ A.

1. *Shenango sandstone*, ... visible, 20′
2. Shales and concealed, ... 35′
3. *Meadville Upper Limestone*, ... 2
4. Concealed to level of Creek, ... 30

The sandstone is here very massive, and forms a bold cliff along the stream; a cascade 20′ high affords excellent water power at the saw mill.

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The base of the sandstone in the section lies 75′ above the level of Sugar lake, 2½ miles to the southeast. There is a considerable dip in that direction, so that at the lake the sandstone is only 30′above the water, as is shown by a row of immense blocks of the sandstone, none being seen on the slope above.

A line of large springs also issue from a little below the horizon of the sandstone blocks. Such springs are nearly always found at its base.

About one and a half miles south of the lake a long high ridge of land rises 400′ above the lake. This is high enough to catch the *ferriferous limestone*, unless the drift which covers up everything out of sight on the ridge be very deep.

Barometric elevations in Wayne township.

Sugar lake, ...	(above tide,)	1280′
Crossing of road south from the lake, ...	"	1275′
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" " Drake's School House, ...	"	1500′
Deckard P. O., ...	"	1240′
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Cross roads at R. Heath's, ...	"	1370′
School house east from W. Roberts, ...	"	1140′
Cross roads at W. Watson's, ...	"	1290′
" " J. Lubold's School House, ...	"	1440′
Bresler's Flouring Mill, on Sugar creek, ...	"	1090′
W. L. Lubold's, ...	"	1305′
Crossing of Sugar creek at R. Kaster's, ...	"	1140′

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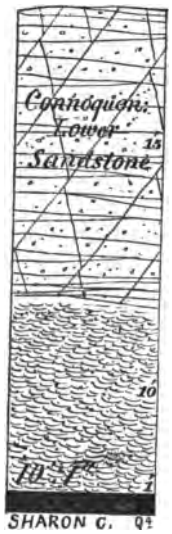

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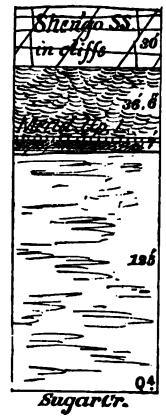

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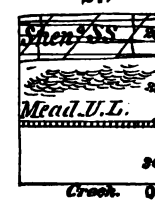

9 Q⁴.

Forks near S. Houtz's,	"	1205′
" next above,	"	1210′
Forks at J. D. Frost's,	"	1330′
" W. McElroy's,	"	1350′
" D. Dupont's,	"	1350′
" A. Pegan's,	"	1370′
" W. Record's,	"	1290′
Crossing of Grass run,	"	1345′
Cross roads at Jannesat's School House,	"	1440′
Crossing of Grass run east of School House,	"	1430′
Cross roads near G. Long's,	"	1520′
George McDaniel's School House,	"	1340′
Forks next east,	"	1320′
" next south east,	"	1310′
Level of Big Sugar creek on John Allen's estate (road crossing,)	"	1290′
Forks at J. Boyd's,	"	1300′
" near W. McDill's School House,	"	1475′

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2. *East Fairfield, Crawford county.*

This township stretches along the east bank of French creek, south of Mead.

Along its central portion parallel with French creek, extends a long high ridge, high enough in some places to hold the *Sharon coal.* The descent to French creek westward is rapid. East of it is the valley of Little Sugar creek, which curves through Wayne township and enters French creek at Cochranton, near the southern corner.

Sharon coal bed.—A small patch of this bed remains on the ridge near the northern line, about a mile east of French creek, on the land of Mr. A. H. Byhm.

In the summer of 1878, Messrs. Lewis and Oliphant, of Pardoe, explored this deposit, because it was reported that 4 feet of coal had been drilled through on the opposite side of French creek, 2 miles distant, and at a much lower level. Four or five holes were drilled on Byhm's hill, and some coal was found in each. Then a shaft was sunk 55′ through drift; but the coal when reached was so broken and mixed with drift deposits that its original thickness and character could not be told. In none of the holes was anything but drift found over the coal—1510′; coal bed 1445′ A. T.

Just south from Mr. Byhm's, a small stream starting on the high divide flows west into French creek, and exposes a very good section for a portion of the distance; and descending it from the Byhm shaft, the following succession occurs, (Fig. 28):

Byhm's run section.

Drift in shaft,	55′
Sharon? Coal,	?
Concealed,	100′
Shenango Sandstone, massive,	25′
Concealed with occasional exposures of flaggy sandstone,	80′
Sharpsville Sandstone, flaggy,	40′
Meadville Lower Limestone,	1′
Sandstone, flaggy, and concealed,	75′
Orangeville Shales, bluish,	2′
Concealed to level of French creek,	80′

The *Shenanago sandstone* here forms a conspicuous cliff around the head of the ravine, and is the same coarse brownish yellow rock filled with *iron balls* that always occurs at this horizon in Crawford county. Mr. Lewis drilled 20′ into it for coal but abandoned it.

The *Sharpsville sandstone* makes very steep slopes along the stream, and many of its layers are very compact.

The *Meadville Lower Limestone* is seen wedged in between layers of sandstone; it is quite siliceous and breaks with the glassy peculiar fracture described on page 84.

Of the *Orangeville shales* only the lowest 2′ are seen; the upper 60′ is here concealed.

About ¾ of a mile above Shaw's Landing, a very good section of the measures below the *Shenango Sandstone* is obtained in descending a ravine on the land of Mr. Adam Shreck, as follows: (Fig. 29.)

Adam Schreck's Section.

Shenango Sandstone,	visible,	10′
Concealed,		5′
Shales, bluish, sandy,		20′
Sandstone, flaggy,		5′
Meadville Upper Limestone,		1′ 6″
Concealed,		10′
Sandstone flaggy, and sandy shales,		30
Shales, slaty,		5′
Sharpsville Upper Sandstone, flaggy,		40′

Meadville Lower Limestone,	1′
Sharpsville Lower Sandstone,	15′
Orangeville blue shales with *Lingulae* and *Discinae*,	55′
Concealed to level of French creek,	110′

The *Upper Limestone* is a perfect mass of smoothly rounded and mostly flat pebbles of shale; nodules of iron; and fragments of *fishes*, including scales, teeth and bones.

The *Lower Limestone* is here found in the center of a quite hard and massive sandstone, from which its weathered surface cannot be distinguished; but a fresh fracture reveals its limy character at a glance.

In the *Orangeville shale* many specimens of *Lingula melia* and *Discina pleuritis* were seen in it, at this locality. The shale is quite fine-grained and has in it a very few thin layers of grit.

Railroad deep cut section.—One mile below Shaw's Landing, and just above the bridge across French creek, the following rocks are seen in a deep cutting along the A. & G. W. R. R: (Fig. 30.)

Corry Sandstone,	10′
Shales, blue,	25′
Concealed,	25′
To level of French creek,	1055′ A. T.

The *Corry Sandstone* comes in layers here 1′ to 2½′ thick, and is a tolerably coarse, brownish-colored rock. Its top lies about 180′ lower than the base of the *Shenango Sandstone.*

The fine-grained, bluish-gray shales contain three or four layers of lean siliceous iron ore 2 to 3 inches thick.

Sharon Conglomerate?—As we ascend the hill-road to the east, just below this, the outcrop of a massive sandstone is seen at 1340′ A. T. up to 1370′ at the summit. The surface is strewn with blocks of pebbly sandstone.

On the ridge road near Mr. J. F. Powell's, an old valley of erosion is seen stretching across from Little Sugar creek to French creek, with a general level of 1240′ A. T. Its side slopes are 100′ to 150′ high.* The lower part of the present valley of Sugar creek has the appearance of being

* See Part I, p. 36.

a recent cut, for its sides are very steep, and often show the horizontal strata cropping out free from Drift.

Barometric Elevations in E. Fairfield.

Forks at R. Cochran's, ...	(above tide),	1100′
" J. Klinger's, ...	"	1270′
Cross-roads at Lafferty's school-house, ...	"	1385′
Forks at T. F. Powell's, ...	"	1340′
" H. Heath's, ...	"	1160′
Lane at James Marley's, ...	"	1175′
Road at J. F. Powell's, ...	"	1250′
" D. McFate's, ...	"	1340′
" school-house, next north,	"	1360′
Cross-roads at R. McFarland's,	"	1390′
Crossing of run at J. Stonebrooks',	"	1305′
Cross-roads at J. Stoddard's, . . .	"	1230′
" A. S. Beatty's, . . .	"	1110′
Forks at E. E. Smith's, ...	"	1445′
" L. Byhm's, ...	"	1510′
" F. Fryermuth's, ...	"	1410′
Cross-roads at D. Verain's, . .	"	1250′
Crossing of Little Sugar creek, next east, ...	"	1175′
J. Champage's, forks of road, . . .	"	1200′
Crossing of Sugar creek at G. Mill,	"	1160′
Forks at H. Stitzer's, ...	"	1180′
" R. McFate's, ...	"	1200′

30.

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3. Union, in Crawford County.

This township occupies the triangular area between French creek and Conneaut Lake creek. Small streams descend from its central high land both ways. Its northern line follows a low valley, through which the A. & G. W. R. R. passes, from French creek two miles below Meadville, over to Conneaut Lake creek at Geneva. Some of the elevated land rises high enough to take in the *Sharon Coal.*

On the land of Mr. Jno. Klipple the *Sharon Coal* out-

Just west from this, one fourth of a mile, on the land of Mr. Jesse McEntire, the coal was once mined quite extensively, though none has been taken out for the past twenty years.

It was, according to Mr. McEntire, a genuine *block coal*, though the central part had a tendency to run into *cannel*, and varied in thickness from 2′ to 8′. It was hauled to Erie and also to Meadville a long time ago.

The coal lies 25′ beneath the highest surface; over it, broken sandstone, mixed with clay, 10′; the rest *Drift*. At other places, where the sandstone had been entirely eroded, the coal was worked by stripping off 5′ to 8′ of *Drift*. The area of workable coal was probably 6 or 7 acres. It was used by smiths, and seems to have been tolerably pure in parts of the bed.

Quarries.—About one mile southwest from McEntire's, on the land of Mr. Jackson, the *Shenango sandstone* has been extensively quarried by the A. & G. W. R. R. Company for building bridges, arches, &c. The base of the sandstone, seen along a small run west from the quarry, comes 80′ below the level of the coal at McEntire's. Only 10′ of the sandstone was quarried; a coarse brown rock, containing multitudes of *iron balls* and *fish remains*. These are especially numerous along the planes of bedding, between the layers, and very greatly mar the looks of the blocks when dressed. These quarries have been almost abandoned of late years, the company getting most of its stone now at Berea, in Ohio.

One half mile east from the Jackson quarries, and 50′ higher, we come to the base of the *Sharon Conglomerate* which makes a cliff around the hill, often with a perpendicular face of 20′.

It is a coarse grayish-white rock and contains many quartz pebbles. Where the top of this stratum is exposed in the road near Mr. Unger's it is furrowed with glacial striæ (direction S. 30 E. magnetic. Elevation 1340′ A. T.

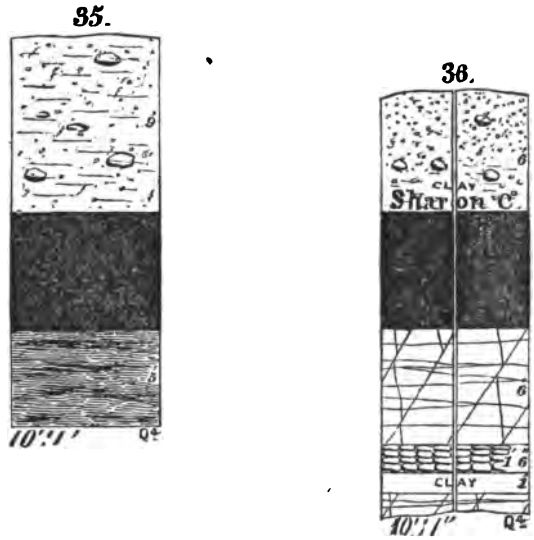
The hill top rises to 1390′ A. T. but no coal has been found in the interval. As this place is nearly south from where

the coal occurs on the McEntire property, it looks as if it were outside the rim of a local coal marsh.

As we descend the hill, on the opposite side from where the ice scratches are seen, I got the following section: (Fig. 37.)

Unger's run section.

Concealed,	50′
Sharon Conglomerate,	20′
Concealed,	55′
Shenango sandstone, (base,)	10′
Blue shales,	15′
Meadville Upper Limestone,	1′



The *Sharon Conglomerate* top was seen one fourth of a mile north from Unger's run.

The interval of 55′ appears to consist chiefly of shales, though it was mostly concealed.

The *Shenango Sandstone* is only exposed for 10′ at its base, and there is probably as much more concealed above.

The interval between the *Shenango Sandstone* and *Limestone* is exceptionally small, and consists entirely of fine bluish-gray shales.

The *Meadville Upper Limestone* is seen in the bed of the 10 Q⁴.

run below the old mill-dam, and is quite hard, breaking with glassy fracture and containing *fish remains.*

Quarries. A short distance south from Unger's run the *Sharon Conglomerate* has been quarried on the land of Mr. D. P. Clennahan; its top seamed with *glacial furrows;* some S. 30 E.; others S. 40° E. magnetic.*

A *high knob*, about one mile from Mr. Clennahan's on the lands of T. J. and O. K. Miller, takes in a considerable area of the *Sharon coal*, (mined to a small extent,) and rises 70′ above the coal: (Fig. 38.)

Miller's knob section.

Concealed from top of hill,	15′
Connoquenessing Lower sandstone,	40′
Shales bluish gray,	15′
Sharon coal bed, (1330′ A. T.,)	3′
Concealed,	10′
Sharon Conglomerate, massive,	visible, 10′

The *Sharon coal* is here 30′ higher than the scratches on the sandstone at Clennahan's. Mr. T. J. Miller sunk a shaft 20′ deep to it, and found it too thin to mine. But it was thick enough to mine on the east side of the road, on the land of Mr. O. K. Miller. A great many tons of tolerably fair coal were taken out of a drift for domestic use; but the bed varied in thickness, 3′ to nothing, often slaty, and otherwise impure even where of workable thickness.

The *Connoquenessing Lower Sandstone* is seen along the road which passes over the hill above the coal; a coarse grayish white rock; in some portions quite micaceous; weathering away very readily; and scratched by ice, S. 35° E. magnetic.

The *Sharon Conglomerate* makes a bold outcrop down in the field below Mr. O. K. Miller's, as a very coarse pebbly grayish white stratum, from which immense blocks have been detached, which now lie scattered over the ground.

The *Sharon coal* also is visible, in a spring, on the land of Robert Ransom, one mile east from Miller's, two feet

[* This shows that the ice moved in two different directions at two different times, and is one evidence against the power of ice to erode the surface; for otherwise the first set of scratches would be removed by the second ice current.—J. P. L.]

thick; but it has never been mined except to a small extent by stripping.

Quarry. A short distance southwest from Miller's the *Sharon Conglomerate* has been quarried for shipment on the A. & G. W. R. R. This is on the land of Mr. Henry, to the right of the road leading to Atlantic Station. It is a rather hard reddish-white sandstone. A curious *vertically stemmed fucoid* is seen in the top-most layer. It contains *fish remains*, and some iron balls; and is much cross bedded. A dip of 2° to the southeast is visible at the quarry. Top of rock, 180′ above A. & G. W. R. R. at Atlantic Station,=1328′ A. T.

Quarry. About three fourths of a mile west from Henry's quarry, and nearly one half mile east from the Atlantic Station, on the land of Mr. Blair, is a quarry in the *Shenango Sandstone* exactly 25′ thick; a tolerably coarse brown sandstone; soft; splitting readily into blocks of almost any desired size; and containing vast quantities of *iron balls* and *fish fragments* in scattered layers, principally near the top. Stone from this quarry is also shipped on A. & G. W. R. R. to various points for building purposes.—Top, 70′ below top of Henry's quarry in the Sharon Conglomerate; *i. e.* 1258′ A. T.

A short distance below where the road crosses McQuiston's run, one mile north from Atlantic, the bottom of the *Orangeville shale* is seen, and 20′ of the blue shales themselves appear in the side of the bluff along the run, resting on the top of a sandstone, at 1030′ A. T.

A knob in the southwestern corner of this township on the land of Mr. Jno. Shepard, rises to 1420′ A. T. One of the *Connoquenessing sandstones* forms its summit; probably the *Upper*, since, further west along the road, we come to the top of the *Sharon Conglomerate* at 1300′ A. T.

Quarry. Here the *Sharon Conglomerate* has been extensively quarried on the land of Mr. Mayo. Top (as above) 1300′ A. T.

Glacial striæ are seen here—S. 30° E. Magnetic.

The *Shenango Sandstone* is seen making a steep bluff, 75′ lower down on the hill-side.

Where the Atlantic Road crosses Henry run, the following is seen in descending the steep hill slope.

Henry run section.

Sharpsville Upper Sandstone, flaggy,	50′
Meadville Lower Limestone, (1115′ A. T.,)	1′
Sharpsville Lower Sandstone, flaggy,	15′
Orangeville shale in bed of stream,	—

The *Sharpsville Upper Sandstone*, in layers ½′ to 2′ thick, (one 4′) very fine-grained, bluish-white; holding a species of *Rhynchonella;* has been quarried to some extent on the bank of the stream.

Meadville Lower Limestone juts out of the bank in large angular masses; breaks with a glassy fracture and is quite siliceous. Here as nearly everywhere else it is wedged in between two masses of sandstone.

The top of the *Orangeville shale* is seen in the bed of the stream, containing a great many *Lingulæ.*

In the vicinity of Stony Point, near the northern line of the township, the *Shenango Sandstone* is frequently seen. At the railroad station its top comes near A. & G. W. R. R. level, 1284′ A. T.

A knob on the land of Wm. Mushrush, one mile southwest from Stony Point, rises to 1335′ A. T., and the *Sharon coal* is reported 2′ to 3′ thick, 5′ below the soil, 70′ above the *Shenango Sandstone* seen one half mile north.

Drift mound:—A large round hill of gravel, sand and bowlders occurs on the land of Mr. D. M. Calvin, two miles south from Stony Point and just west from the A. & G. W. R. R., and has been largely quarried for ballast and fillings along the railroad. It is simply a hillock of *Drift*, 50′ of which is visible in the quarry; as much more lies higher to the top of the hill; and no one knows how much more lies beneath the quarry.

Barometric elevations in East Fallowfield:

Forks of road at Jon. Shepard's,	(above tide,)	1400′
Cross roads near S. Lingo's,	"	1335′
" " H. Blair's,	"	1135′
" " S. & W. Elsworth's,	"	1065′
" " G. Gaston's,	"	1075′
Crossing of Crooked creek, west,	"	1000′

Forks of road near Joseph Duncan's,	"	1070′
Cross roads near Jno. Kee's,	"	1310′
" next south,	"	1320′
" near Joseph Henry's,	"	1355′
Forks at Town House,	"	1290′
" next north,	"	1310′
Cross roads near Jesse McEntire's,	"	1340′
Lane near J. W. McEntire's,	"	1310′
Forks next east,	"	1290′
" "	"	1290′
Cross roads east from Stony Point,	"	1270′
Forks near Wm. Carman's,	"	1310′
Cross roads near S. De Arment's,	"	1280′
Cross roads due north of township line,	"	1255′
" " west of last,	"	1250′
Forks near J. McVicker's,	"	1210′
" " S. H. Haller's,	"	1120′
" " J. Shellito's,	"	1075′
Cross roads near S. Greenlee's,	"	1050′
" " D. M. Calvin's,	"	1255′
" " crossing, above Randolph's run,	"	1040′

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7. *West Fallowfield in Crawford county.*

This township stretches along the west side of Crooked creek. A high plateau extends north and south along its western margin, from which the rain-fall descends into the creek. The northern end of the township is swampy and the water flows into Pymatuning creek.

Just west from Adamsville a small stream breaks over the *Shenango Sandstone* with a perpendicular fall, and descending to Crooked creek exposes the following Fig. 39:

Adamsville Section.

Shenango S. S. massive,	visible,	10′
Blue shales and flaggy sandstone,		23′
Meadville Upper Limestone, (1215′ A. T.,)		1′
Blue shales and flaggy sandstone,		35′
Sharpsville Upper sandstone, flaggy,		50′
Meadville Lower Limestone,		1′
Sharpsville Lower sandstone, flaggy,		10′
Orangeville shale (a few feet) and concealed to creek,		120′

The *Shenango Sandstone* is quite massive and forms a steep bluff and cliff around the hill. It is the same coarse brownish gray iron bearing rock as elsewhere.

run below the old mill-dam, and is quite hard, breaking with glassy fracture and containing *fish remains.*

Quarries. A short distance south from Unger's run the *Sharon Conglomerate* has been quarried on the land of Mr. D. P. Clennahan; its top seamed with *glacial furrows;* some S. 30 E.; others S. 40° E. magnetic.*

A *high knob*, about one mile from Mr. Clennahan's on the lands of T. J. and O. K. Miller, takes in a considerable area of the *Sharon coal*, (mined to a small extent,) and rises 70′ above the coal: (Fig. 38.)

Miller's knob section.

Concealed from top of hill,	15′
Connoquenessing Lower sandstone,	40′
Shales bluish gray,	15′
Sharon coal bed, (1330′ A. T.,)	3′
Concealed,	10′
Sharon Conglomerate, massive,	visible, 10′

The *Sharon coal* is here 30′ higher than the scratches on the sandstone at Clennahan's. Mr. T. J. Miller sunk a shaft 20′ deep to it, and found it too thin to mine. But it was thick enough to mine on the east side of the road, on the land of Mr. O. K. Miller. A great many tons of tolerably fair coal were taken out of a drift for domestic use; but the bed varied in thickness, 3′ to nothing, often slaty, and otherwise impure even where of workable thickness.

The *Connoquenessing Lower Sandstone* is seen along the road which passes over the hill above the coal; a coarse grayish white rock; in some portions quite micaceous; weathering away very readily; and scratched by ice, S. 35° E. magnetic.

The *Sharon Conglomerate* makes a bold outcrop down in the field below Mr. O. K. Miller's, as a very coarse pebbly grayish white stratum, from which immense blocks have been detached, which now lie scattered over the ground.

The *Sharon coal* also is visible, in a spring, on the land of Robert Ransom, one mile east from Miller's, two feet

[* This shows that the ice moved in two different directions at two different times, and is one evidence against the power of ice to erode the surface; for otherwise the first set of scratches would be removed by the second ice current.—J. P. L.]

thick; but it has never been mined except to a small extent by stripping.

Quarry. A short distance southwest from Miller's the *Sharon Conglomerate* has been quarried for shipment on the A. & G. W. R. R. This is on the land of Mr. Henry, to the right of the road leading to Atlantic Station. It is a rather hard reddish-white sandstone. A curious *vertically stemmed fucoid* is seen in the top-most layer. It contains *fish remains*, and some iron balls; and is much cross bedded. A dip of 2° to the southeast is visible at the quarry. Top of rock, 180′ above A. & G. W. R. R. at Atlantic Station,=1328′ A. T.

Quarry. About three fourths of a mile west from Henry's quarry, and nearly one half mile east from the Atlantic Station, on the land of Mr. Blair, is a quarry in the *Shenango Sandstone* exactly 25′ thick; a tolerably coarse brown sandstone; soft; splitting readily into blocks of almost any desired size; and containing vast quantities of *iron balls* and *fish fragments* in scattered layers, principally near the top. Stone from this quarry is also shipped on A. & G. W. R. R. to various points for building purposes.—Top, 70′ below top of Henry's quarry in the Sharon Conglomerate; *i. e.* 1258′ A. T.

A short distance below where the road crosses McQuiston's run, one mile north from Atlantic, the bottom of the *Orangeville shale* is seen, and 20′ of the blue shales themselves appear in the side of the bluff along the run, resting on the top of a sandstone, at 1030′ A. T.

A knob in the southwestern corner of this township on the land of Mr. Jno. Shepard, rises to 1420′ A. T. One of the *Connoquenessing sandstones* forms its summit; probably the *Upper*, since, further west along the road, we come to the top of the *Sharon Conglomerate* at 1300′ A. T.

Quarry. Here the *Sharon Conglomerate* has been extensively quarried on the land of Mr. Mayo. Top (as above) 1300′ A. T.

Glacial striæ are seen here—S. 30° E. Magnetic.

The *Shenango Sandstone* is seen making a steep bluff, 75′ lower down on the hill-side.

Where the Atlantic Road crosses Henry run, the following is seen in descending the steep hill slope.

Henry run section.

Sharpsville Upper Sandstone, flaggy,	50′
Meadville Lower Limestone, (1115′ A. T.,)	1′
Sharpsville Lower Sandstone, flaggy,	15′
Orangeville shale in bed of stream,	—

The *Sharpsville Upper Sandstone*, in layers ½′ to 2′ thick, (one 4′) very fine-grained, bluish-white; holding a species of *Rhynchonella;* has been quarried to some extent on the bank of the stream.

Meadville Lower Limestone juts out of the bank in large angular masses; breaks with a glassy fracture and is quite siliceous. Here as nearly everywhere else it is wedged in between two masses of sandstone.

The top of the *Orangeville shale* is seen in the bed of the stream, containing a great many *Lingulæ.*

In the vicinity of Stony Point, near the northern line of the township, the *Shenango Sandstone* is frequently seen. At the railroad station its top comes near A. & G. W. R. R. level, 1284′ A. T.

A knob on the land of Wm. Mushrush, one mile southwest from Stony Point, rises to 1335′ A. T., and the *Sharon coal* is reported 2′ to 3′ thick, 5′ below the soil, 70′ above the *Shenango Sandstone* seen one half mile north.

Drift mound:—A large round hill of gravel, sand and bowlders occurs on the land of Mr. D. M. Calvin, two miles south from Stony Point and just west from the A. & G. W. R. R., and has been largely quarried for ballast and fillings along the railroad. It is simply a hillock of *Drift*, 50′ of which is visible in the quarry; as much more lies higher to the top of the hill; and no one knows how much more lies beneath the quarry.

Barometric elevations in East Fallowfield:

Forks of road at Jon. Shepard's,	(above tide,)	1400′
Cross roads near S. Lingo's,	"	1335′
" " H. Blair's,	"	1135′
" " S. & W. Elsworth's,	"	1065′
" " G. Gaston's,	"	1075′
Crossing of Crooked creek, west,	"	1000′

Forks of road near Joseph Duncan's,	"	1070′
Cross roads near Jno. Kee's,	"	1310′
" next south,	"	1320′
" near Joseph Henry's,	"	1355′
Forks at Town House,	"	1290′
" next north,	"	1310′
Cross roads near Jesse McEntire's,	"	1340′
Lane near J. W. McEntire's,	"	1310′
Forks next east,	"	1290′
" "	"	1290′
Cross roads east from Stony Point,	"	1270′
Forks near Wm. Carman's,	"	1310′
Cross roads near S. De Arment's,	"	1280′
Cross roads due north of township line,	"	1255′
" " west of last,	"	1250′
Forks near J. McVicker's,	"	1210′
" " S. H. Haller's,	"	1120′
" " J. Shellito's,	"	1075′
Cross roads near S. Greenlee's,	"	1050′
" " D. M. Calvin's,	"	1255′
" " crossing, above Randolph's run,	"	1040′

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7. *West Fallowfield in Crawford county.*

This township stretches along the west side of Crooked creek. A high plateau extends north and south along its western margin, from which the rain-fall descends into the creek. The northern end of the township is swampy and the water flows into Pymatuning creek.

Just west from Adamsville a small stream breaks over the *Shenango Sandstone* with a perpendicular fall, and descending to Crooked creek exposes the following Fig. 39:

Adamsville Section.

Shenango S. S. massive,	visible, 10′
Blue shales and flaggy sandstone,	23′
Meadville Upper Limestone, (1215′ A. T.,)	1′
Blue shales and flaggy sandstone,	35′
Sharpsville Upper sandstone, flaggy,	50′
Meadville Lower Limestone,	1′
Sharpsville Lower sandstone, flaggy,	10′
Orangeville shale (a few feet) and concealed to creek,	120′

The *Shenango Sandstone* is quite massive and forms a steep bluff and cliff around the hill. It is the same coarse brownish gray iron bearing rock as elsewhere.

The *Meadville Upper Limestone* is a mere mass of pebbles of shale, and fragments of *fishes*, with many *shells*. The shale pebbles are flattened as usual.

The *Sharpsville Upper Sandstone* consists of layers of fine-grained light brown sandstone 1′ to 2′ thick, with some of them separated by thin streaks of shale.

The *Meadville Lower Limestone* is a very hard calcareo-silicious rock, jutting out of the bank of the stream, and scattered in large masses, with rounded angles along its bed.

The valley of Crooked creek is deeply buried by *Drift* so that very few exposures are seen along it, and none on the highlands.

Cross roads near F. Bealer's,	(above tide,)	1060′
" at western line of township near A. Weer's,	"	1300′
Cross roads in Adamsville,	"	1040′
Forks at Hartstown,	"	1040′
" next east of Hartstown,	"	1030′
Crossing Crooked creek,	"	1010′

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8. *South Shenango, in Crawford County.*

This township lies along the Mercer county line, and east bank of the Shenango river, into which it drains.

The south part rises high enough to take in the *Sharon coal* and *Sharon iron ore*, which last was once mined on the land of Mr. Jas. Snodgrass.

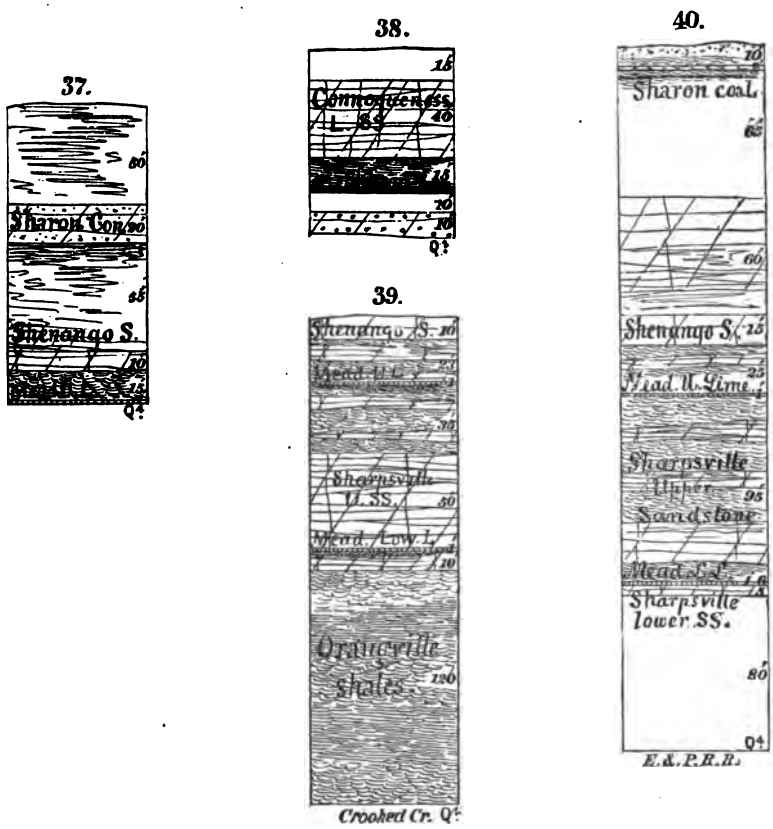
Descending from the summit at Mr. Jas. Snodgrass' down a ravine past the stone quarries, the following interesting section is seen (Fig. 40):

Snodgrass' Section.

Débris and blue shale,	10′
Sharon iron ore,	2′
Shales, containing *Sharon coal (?)*,	?
Concealed to top of quarry rock, on land of Wm. Snodgrass,	65′
Sandstone, massive at top, but flaggy and concealed below,	60′
Shenango sandstone,	15′
Blue shales, flaggy sandstone, and concealed,	25′
Meadville Upper limestone,	1′
Sharpsville Upper sandstone, flaggy, and shales, with some massive layers near the bottom,	95′

Meadville Lower limestone (1065 A. T.), ... 1′ 6″
Sharpsville Lower sandstone, flaggy, ... 5′
Concealed to level of the Erie and Pittsburgh R. R., at Jamestown, ... 80′

The *Sharon ore* was mined here by stripping, up to the year 1855, and shipped to the furnaces at Greenville and



Middlesex, in Mercer county. Mr. Snodgrass, who is responsible for my information with regard to the *ore*, states that it came in "pots" or bowl-shaped deposits, and was 2′ thick in a single solid bed. Above it lies 6′ to 12′ of débris. Mr. Snodgrass states that sometimes 4′ to 5′ of blue slate occurred above the ore in the deepest places.

A thin seam of coal was often found in the shales below

the ore, probably the *Sharon bed*, but possibly one of its riders.

The extensive quarries of Mr. Wm. Snodgrass are in the top layers of a sandstone which is quite massive, but gradually becomes flaggy below, and contains great numbers of a plant very much resembling *Lepidodendron Gaspianum, D.*, or possibly still closer, *Lepidodendron* Sp., ? of the Geol. of Penn'a, 1858, Vol. II, Part II, page 829, Plate 21, Fig. 2. If this be the *Sharon Conglomerate*, and there be nothing but shales in the concealed interval of 65′ above it, then the coal under the iron ore cannot be the *Sharon* bed, but must be one of its *riders*. Blocks of a white sandstone, however, are scattered over the surface in the interval, and may possibly have come from a higher portion of the *Sharon Conglomerate*.

Whatever doubt there may be with regard to the top of the quarry rock, there is none whatever concerning the equivalency of the *Shenango Sandstone* and the *two limestones* below it.

The *Shenango Sandstone* is somewhat massive, and has been quarried just below where the road crosses the little stream at the bridge. It contains, as usual, *fish remains*, and its characteristic *iron ore balls*.

The *Upper Limestone*, hard and compact, lies 25′ below the base of the *Shenango Sandstone*, and contains many *fish remains*.

The *Sharpsville sandstone* occupies the lower half of the 95′ interval, and some of the more massive layers near the bottom of the mass have been quarried.

The *Lower Limestone* floors the bottom of the run, and is finely shown, exhibiting the glassy fracture peculiar to these limestones.

The *Sharpsville Lower Sandstone* shows only 5′ of itself along the run; but along the public road further west, near the Gibson oil well, 12′ of it is seen, and then the *Orangeville shale* begins, at the top of which the Gibson well commences.

Gibson Well Section (Fig. 41).

Shenango Sandstone (as above),	15′
Blue shales, flaggy S. S., and concealed,	25′
Meadville Upper Limestone,	1′
Sharpsville Upper S. S., flaggy and shales,	95′
Meadville Lower Limestone,	1′ 6″
Sharpsville Lower S. S., flaggy,	12′

Well Record.

"Slaty soapstone and hard shells,"	90′
"Sandstone, blue, fine,"	20′
"Slate, blue,"	65′
"2ond Sandstone, estimated,"	25′
"Slate, blue,"	90′
"3rd Sandstone,"	18′
"Soft slate and soapstone,"	92′
"*Red rock* and hard shale,"	100′
"Hard sandy slate,"	50′
"*Black slate*,"	200′
"*Unknown*,"	315′
To bottom at	1065′

The words "*2nd*" and "*3rd sand*" occurring in this record have no reference to the *Venango 2nd and 3rd Oil Sands;* for the *Venango 3rd Sand* ought to come in this well where we read "hard, sandy slate, 50′," with *its base* about 735′ below the base of the *Sharon Conglomerate*, (*Venango Second Mountain Sand.*)

The "2d sand, estimated 25′," represents the 75′ rock in the Sharon well, the 78′ rock at New Castle, and the 124′ rock at Beaver Falls.

The "black slate, 200′," should not be interpreted as a *bituminous coal slate*, but only as a dark-colored shale. No true *black slate* is found at this horizon in any of the numerous borings along the Shenango valley; nor in the measures where they come to the surface as dark-bluish shales and thin sand-layers beneath the *Venango Third Sand*, throughout Erie county.

About one mile north from Jamestown, a small stream descending from the highlands to the Shenango cuts down to the *Shenango Sandstone*, just below where the run crosses the road on the land of Mr. Mathew McElhaney, and there the following exposure is seen (Fig. 42):

McElhany Section.

Shenango Sandstone, ... 20′
Blue shale, ... 20′
Meadville Upper Limestone (1200′ A. T.), ... ½′

Quarry. The *Shenango Sandstone* has been quarried here, and makes an excellent building stone, being easily dressed, and splitting out in large massive blocks; it is a coarse buffish-brown rock as usual, and contains *fish remains* and *iron ore balls.*

The *Limestone* is here a regular *fish bed*, containing also flattened pebbles of shale and fine grit.

On the land of Mr. P. Miller just east from the State road a deep ravine shows the following rocks: (Fig. 43.)

Miller's Section.

Sharpsville Upper	Sandstone, shaly, ... 15′ Quarry S. in layers, 1 to 3′, . . 10′ Sandstone, flaggy, ... 20	45′
Meadville Lower Limestone, siliceous, (1120′ A. T.,) . . .		1′ 6″
Sharpsville Lower Sandstone, flaggy, ...		10′
Orangeville shale, ...		visible, 35′
Concealed to level of the Shenango, ...		105′

Mr. Miller has quite an extensive quarry here in a rather fine-grained buffish-gray somewhat micaceous rock, in layers 1′ to 3′ thick.

The *Orangeville shale* is of a rather dark blue color; and three or four layers of sandstone are seen, one of them 3′.

Barometric elevations in S. Shenango.

Forks of road near J. McElhaney's, ...	(above tide,)	1140′
" " W. Crawford's, ...	"	1190′
" " Mathew McElhaney's, ...	"	1240′
" " Scott A. Marshall's, ...	"	1255′
" at Marshall's corners, ...	"	1260′
" " J. Vance's, ...	"	1115′
Level of the Shenango near McLean s Corners, . .	"	980′
Cross roads near J. & S. Gallagher's, ...	"	995′
Level of the Shenango near the last, ...	"	915′
Cross roads near T. Lewis's, ...	"	1190′
" " J. N. Wade's, ...	"	1265′
" " Jas. Jamison's, ...	"	1245′
Cross roads near J. Picker's, ...	"	1195′
Forks near A. Glenn's, ...	"	1220′
Cross roads near J. Austin's Cheese Factory, . . .	"	1140′

R. R. crossing, due west,	(above tide),	1095′
Forks next west,	"	1085
Cross roads near W. Mullen's,	"	1040′
Forks near A. Glenn's,	"	1020′
" " P. Fonner's,	"	1020′
Cross roads near T. W. Hill's,	"	1070·
" " S. Coursen's,	"	1210′
Forks near R. B. Dickey's,	"	1225′

9. *West Shenango, in Crawford county.*

This township occupies the southwest corner of the county; along the Shenango river; the northern part of the township being reduced to a narrow strip.

The *Conglomerate* rocks are eroded away from its surface; and the underlying measures are concealed by deep *Drift*, so that not a single section can be obtained.

The *Sharpsville Upper Sandstone* has been quarried near the southwestern corner of the township to a considerable extent on the land of Mr. Floch. It is made up of thin layers of sandstone from 4″ to 18″ thick, some of which make very good flagging.

This is the locality where the *Berea Grit* of Ohio was supposed to pass into Pennsylvania, being wrongly identified with the *Sharpsville Sandstone;* but the true *Berea Grit* is to be found 100′ lower in the series; being probably the 20′ sandstone struck at the depth of 90′ in the Gibson well near Jamestown.

Cross-roads in Turnersville,	(above tide),	1050′
Level of the Shenango to the east,	"	980′
Forks at P. Yokes',	"	1055′
Forks near church at I. Cook's,	"	1105′
" " D. McCormick's,	"	1040′
R. R. crossing next north,	"	1035′
Cross-roads near H. Frenen's,	"	1000′
Level of the Shenango at road-crossing next east,	"	915′

10. *North Shenango, in Crawford County.*

This township lies next north of South Shenango town-

run below the old mill-dam, and is quite hard, breaking with glassy fracture and containing *fish remains.*

Quarries. A short distance south from Unger's run the *Sharon Conglomerate* has been quarried on the land of Mr. D. P. Clennahan; its top seamed with *glacial furrows;* some S. 30 E.; others S. 40° E. magnetic.*

A *high knob*, about one mile from Mr. Clennahan's on the lands of T. J. and O. K. Miller, takes in a considerable area of the *Sharon coal*, (mined to a small extent,) and rises 70′ above the coal: (Fig. 38.)

Miller's knob section.

Concealed from top of hill,	15′
Connoquenessing Lower sandstone,	40′
Shales bluish gray,	15′
Sharon coal bed, (1330′ A. T.,)	3′
Concealed,	10′
Sharon Conglomerate, massive,	visible, 10′

The *Sharon coal* is here 30′ higher than the scratches on the sandstone at Clennahan's. Mr. T. J. Miller sunk a shaft 20′ deep to it, and found it too thin to mine. But it was thick enough to mine on the east side of the road, on the land of Mr. O. K. Miller. A great many tons of tolerably fair coal were taken out of a drift for domestic use; but the bed varied in thickness, 3′ to nothing, often slaty, and otherwise impure even where of workable thickness.

The *Connoquenessing Lower Sandstone* is seen along the road which passes over the hill above the coal; a coarse grayish white rock; in some portions quite micaceous; weathering away very readily; and scratched by ice, S. 35° E. magnetic.

The *Sharon Conglomerate* makes a bold outcrop down in the field below Mr. O. K. Miller's, as a very coarse pebbly grayish white stratum, from which immense blocks have been detached, which now lie scattered over the ground.

The *Sharon coal* also is visible, in a spring, on the land of Robert Ransom, one mile east from Miller's, two feet

[* This shows that the ice moved in two different directions at two different times, and is one evidence against the power of ice to erode the surface; for otherwise the first set of scratches would be removed by the second ice current.—J. P. L.]

thick; but it has never been mined except to a small extent by stripping.

Quarry. A short distance southwest from Miller's the *Sharon Conglomerate* has been quarried for shipment on the A. & G. W. R. R. This is on the land of Mr. Henry, to the right of the road leading to Atlantic Station. It is a rather hard reddish-white sandstone. A curious *vertically stemmed fucoid* is seen in the top-most layer. It contains *fish remains*, and some iron balls; and is much cross bedded. A dip of 2° to the southeast is visible at the quarry. Top of rock, 180′ above A. & G. W. R. R. at Atlantic Station,=1328′ A. T.

Quarry. About three fourths of a mile west from Henry's quarry, and nearly one half mile east from the Atlantic Station, on the land of Mr. Blair, is a quarry in the *Shenango Sandstone* exactly 25′ thick; a tolerably coarse brown sandstone; soft; splitting readily into blocks of almost any desired size; and containing vast quantities of *iron balls* and *fish fragments* in scattered layers, principally near the top. Stone from this quarry is also shipped on A. & G. W. R. R. to various points for building purposes.—Top, 70′ below top of Henry's quarry in the Sharon Conglomerate; *i. e.* 1258′ A. T.

A short distance below where the road crosses McQuiston's run, one mile north from Atlantic, the bottom of the *Orangeville shale* is seen, and 20′ of the blue shales themselves appear in the side of the bluff along the run, resting on the top of a sandstone, at 1030′ A. T.

A knob in the southwestern corner of this township on the land of Mr. Jno. Shepard, rises to 1420′ A. T. One of the *Connoquenessing sandstones* forms its summit; probably the *Upper*, since, further west along the road, we come to the top of the *Sharon Conglomerate* at 1300′ A. T.

Quarry. Here the *Sharon Conglomerate* has been extensively quarried on the land of Mr. Mayo. Top (as above) 1300′ A. T.

Glacial striæ are seen here—S. 30° E. Magnetic.

The *Shenango Sandstone* is seen making a steep bluff, 75′ lower down on the hill-side.

Where the Atlantic Road crosses Henry run, the following is seen in descending the steep hill slope.

Henry run section.

Sharpsville Upper Sandstone, flaggy,	50′
Meadville Lower Limestone, (1115′ A. T.,)	1′
Sharpsville Lower Sandstone, flaggy,	15′
Orangeville shale in bed of stream,	—

The *Sharpsville Upper Sandstone*, in layers ½′ to 2′ thick, (one 4′) very fine-grained, bluish-white; holding a species of *Rhynchonella;* has been quarried to some extent on the bank of the stream.

Meadville Lower Limestone juts out of the bank in large angular masses; breaks with a glassy fracture and is quite siliceous. Here as nearly everywhere else it is wedged in between two masses of sandstone.

The top of the *Orangeville shale* is seen in the bed of the stream, containing a great many *Lingulæ.*

In the vicinity of Stony Point, near the northern line of the township, the *Shenango Sandstone* is frequently seen. At the railroad station its top comes near A. & G. W. R. R. level, 1284′ A. T.

A knob on the land of Wm. Mushrush, one mile southwest from Stony Point, rises to 1335′ A. T., and the *Sharon coal* is reported 2′ to 3′ thick, 5′ below the soil, 70′ above the *Shenango Sandstone* seen one half mile north.

Drift mound:—A large round hill of gravel, sand and bowlders occurs on the land of Mr. D. M. Calvin, two miles south from Stony Point and just west from the A. & G. W. R. R., and has been largely quarried for ballast and fillings along the railroad. It is simply a hillock of *Drift*, 50′ of which is visible in the quarry; as much more lies higher to the top of the hill; and no one knows how much more lies beneath the quarry.

Barometric elevations in East Fallowfield:

Forks of road at Jon. Shepard's,	(above tide,)	1400′
Cross roads near S. Lingo's,	"	1335′
" " H. Blair's,	"	1135′
" " S. & W. Elsworth's,	"	1065′
" " G. Gaston's,	"	1075′
Crossing of Crooked creek, west,	"	1000′

Forks of road near Joseph Duncan's,	"	1070′
Cross roads near Jno. Kee's,	"	1310′
" next south,	"	1320′
" near Joseph Henry's,	"	1355′
Forks at Town House,	"	1290′
" next north,	"	1310′
Cross roads near Jesse McEntire's,	"	1340′
Lane near J. W. McEntire's,	"	1310′
Forks next east,	"	1290′
" "	"	1290′
Cross roads east from Stony Point,	"	1270′
Forks near Wm. Carman's,	"	1310′
Cross roads near S. De Arment's,	"	1280′
Cross roads due north of township line,	"	1255′
" " west of last,	"	1250′
Forks near J. McVicker's,	"	1210′
" " S. H. Haller's,	"	1120′
" " J. Shellito's,	"	1075′
Cross roads near S. Greenlee's,	"	1050′
" " D. M. Calvin's,	"	1255′
" " crossing, above Randolph's run,	"	1040′

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7. *West Fallowfield in Crawford county.*

This township stretches along the west side of Crooked creek. A high plateau extends north and south along its western margin, from which the rain-fall descends into the creek. The northern end of the township is swampy and the water flows into Pymatuning creek.

Just west from Adamsville a small stream breaks over the *Shenango Sandstone* with a perpendicular fall, and descending to Crooked creek exposes the following Fig. 39:

Adamsville Section.

Shenango S. S. massive, visible,	10′
Blue shales and flaggy sandstone,	23′
Meadville Upper Limestone, (1215′ A. T.,)	1′
Blue shales and flaggy sandstone,	35′
Sharpsville Upper sandstone, flaggy,	50′
Meadville Lower Limestone,	1′
Sharpsville Lower sandstone, flaggy,	10′
Orangeville shale (a few feet) and concealed to creek,	120′

The *Shenango Sandstone* is quite massive and forms a steep bluff and cliff around the hill. It is the same coarse brownish gray iron bearing rock as elsewhere.

The *Meadville Upper Limestone* is a mere mass of pebbles of shale, and fragments of *fishes*, with many *shells*. The shale pebbles are flattened as usual.

The *Sharpsville Upper Sandstone* consists of layers of fine-grained light brown sandstone 1′ to 2′ thick, with some of them separated by thin streaks of shale.

The *Meadville Lower Limestone* is a very hard calcareo-silicious rock, jutting out of the bank of the stream, and scattered in large masses, with rounded angles along its bed.

The valley of Crooked creek is deeply buried by *Drift* so that very few exposures are seen along it, and none on the highlands.

Cross roads near F. Bealer's,	(above tide,)	1060′
" at western line of township near A. Weer's,	"	1300′
Cross roads in Adamsville,	"	1040′
Forks at Hartstown,	"	1040′
" next east of Hartstown,	"	1030′
Crossing Crooked creek,	"	1010′

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8. *South Shenango, in Crawford County.*

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The south part rises high enough to take in the *Sharon coal* and *Sharon iron ore*, which last was once mined on the land of Mr. Jas. Snodgrass.

Descending from the summit at Mr. Jas. Snodgrass' down a ravine past the stone quarries, the following interesting section is seen (Fig. 40):

Snodgrass' Section.

Débris and blue shale,	10′
Sharon iron ore,	2′
Shales, containing *Sharon coal (?)*,	?
Concealed to top of quarry rock, on land of Wm. Snodgrass,	65′
Sandstone, massive at top, but flaggy and concealed below,	60′
Shenango sandstone,	15′
Blue shales, flaggy sandstone, and concealed,	25′
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Sharpsville Upper sandstone, flaggy, and shales, with some massive layers near the bottom,	95′

Meadville Lower limestone (1065 A. T.), ... 1′ 6″
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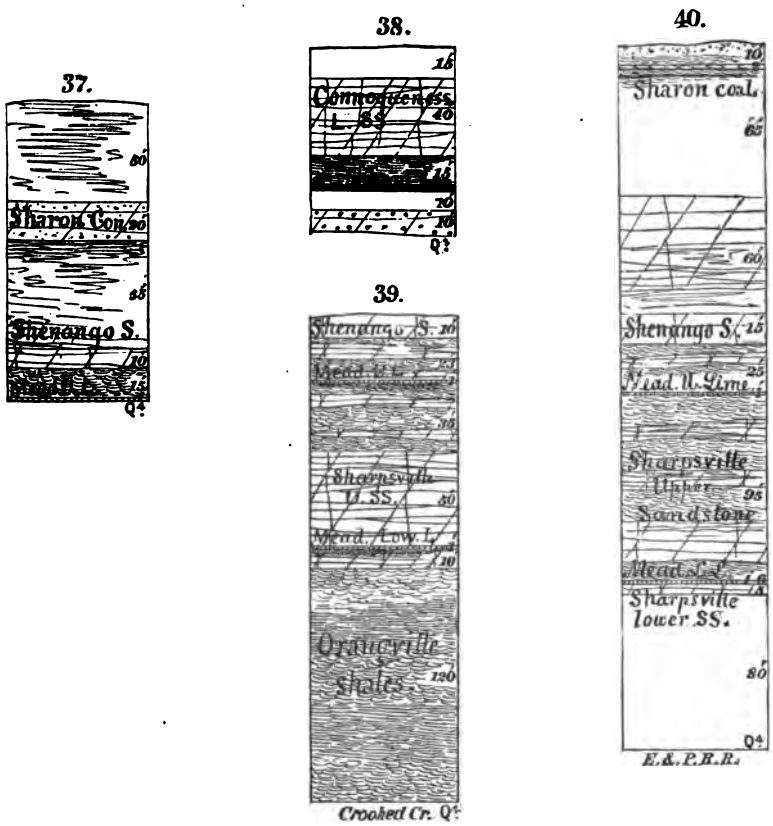

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Miller's Section.

Sharpsville Upper	Sandstone, shaly,	15′	45′
	Quarry S. in layers, 1 to 3′,	10′	
	Sandstone, flaggy,	20	
Meadville Lower Limestone, siliceous, (1120′ A. T.,)			1′ 6″
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Forks near R. B. Dickey's,	"	1225′

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Cross-roads in Turnersville,	(above tide),	1050′
Level of the Shenango to the east,	"	980′
Forks at P. Yokes',	"	1055′
Forks near church at I. Cook's,	"	1105′
" " D. McCormick's,	"	1040′
R. R. crossing next north,	"	1035′
Cross-roads near H. Frenen's,	"	1000′
Level of the Shenango at road-crossing next east,	"	915′

10. *North Shenango, in Crawford County.*

This township lies next north of South Shenango town-

ship, along the Ohio State line. The Shenango river flows through it.

This township, like the one south of it, is completely covered with *Drift*, and has a low and almost uniform level, so that nothing like a section of its rocks can be obtained; but the *Sharpsville Sandstone* forms most of the surface rock beneath the *Drift* along its southern line; and the *Orangeville Shales*, with the rocks intermediate between them and the *Corry Sandstone*, occupy its northern part.

The only rock exposure noticed in the township is at the crossing of Bennett's run, near Mr. T. S. Bennett's, where the outcrop of a flaggy sandstone appears (at 1020′ A. T.), and beneath it crops out a blue shale containing many *Fucoidal* impressions.

Forks of road near A. Marcy's, ...	(above tide),	1170′
Cross-roads near G. Shellito's, ...	"	1140′
" " A. Chapman's, ...	"	1090′
Forks near J. P. Collins', ...	"	1060′
" T. Freeman's, ...	"	1140′
Level of Bennett's run, near D. A. Bennett's, .	"	1020′
Forks of road near T. S. Bennett's, ...	"	1035′
" " S. S. Barrackman's, ...	"	1035′
Level of forks of road in Espyville, ...	"	1040′
Forks near T. McLaughlin's, ...	"	1045′
" G. C. Campbell's, ...	"	1040′
Cross-roads near J. B. Harriett's, ...	"	1040
Forks next west, ...	"	1010′
Crossing of the Shenango next west, ...	"	980′
Forks near C. A. Woodard's, ...	"	995′
" J. C. Dart's, ...	"	1005′

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11. *Pine Township, in Crawford County.*

This township lies on the north side of the Shenango creek.

Pymatuning Swamp occupies its southern end; and as surveyed in 1868 by Col. Worrall, C. E., under instructions from Surveyor General Campbell, its area was determined to be about nine thousand acres. It begins at Hartstown, in West Fallowfield township, and follows the course of the Shenango and its tributaries around to the Ohio line,

in North Shenango township. It therefore covered nearly two thirds of Pine township; but a considerable part of its area has since then been drained. Its general elevation is about 1025′ A. T.

Measurements by Col. Worrall.

From head of swamp at Linesville to outlet of same at B. Pollack's,	4.75	miles; fall,	20.5′
From head at Hartstown to Linesville branch of swamp,	6.25	" "	20.9′
From mouth of Padant's creek to head of swamp,	1.00	" "	2.3
From outlet of swamp to Ohio State line,	3.00	" "	4.5′
From Linesville branch to outlet of swamp,	2.75	" "	3.9′
From head of swamp at Hartstown to Ohio State line,	12.00	" "	29.3′

The swamp supports a dense growth of vegetation, consisting of a great variety of plants, among which the beautiful "Side-Saddle Flower," or *Saracenia purpurea* is found in great abundance along the edges of the marsh, about two miles south from Linesville.

Where the water stood in a more or less continuous sheet we find nothing but the Broad-leaved Flag, or *Typha latifolia*, growing in dense clusters. In some places we find dense growths of Tamarack; in others *Swamp Willow*, *Black Alder*, and *Witch Hazel* constitute the principal flora. The variety of herbs and smaller undergrowth is very great.

Quarry.—About one mile east from Linesville, on the land of Hendrick and Logan, a stratum of sandstone has been quarried to a considerable extent, and there the following is seen (Fig. 44):

Chocolate Shales,	10′
Corry Sandstone (1140′ A. T.),	6′
Blue Shales,	5′

The buff-colored tolerably coarse *Corry Sandstone* contains many conglomerated masses of iron ore balls. The stratum is much broken up, and the layers are seldom thicker than 8″; nevertheless, in a region where sandstone is so scarce it finds a ready sale, and a large amount of it is quarried.

The top of the stratum lies 1140′ above tide, as carefully

determined by two trials from the E. & P. R. R. at Linesville, distant only a mile to the west. This elevation is the basis of its identification with the *Corry Sandstone;* for the top of the *Orangeville shale* near Adamsville (10 miles nearly due south) is 1110′ A. T. The shale is nearly 80′ thick along the Ohio line, and therefore its bottom (or the top of the *Corry Sandstone*) is 1110′—80′=1030′ A. T. This gives 1140′—1030=110′ fall in 10 miles, which agrees well enough with the general dip.

The *Corry Sandstone* is also quarried to a small extent on the land of Mr. Beardsley, a short distance northwest from Linesville, and is the same kind as at Hendricks'.

General elevation of Pymatuning swamp, . .	(above tide),	1025′
Forks of road near S. Odell's, ...	"	1020′
" " E. Seley's, ...	"	1075′
" " L. Bundy's, ...	"	1070′
Cross-roads at eastern limit of Linesville, . . .	"	1045′
Forks near A. C. Rea's, ...	"	1040′
Level of North Branch of Shenango at Linesville, ...	"	1008′
Forks near C. C. Dennis', ...	"	1000′
Crossing Peyton's run, ...	"	1000′
Forks near S. Clark's, ...	"	1000′

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12. Sadsbury, in Crawford county

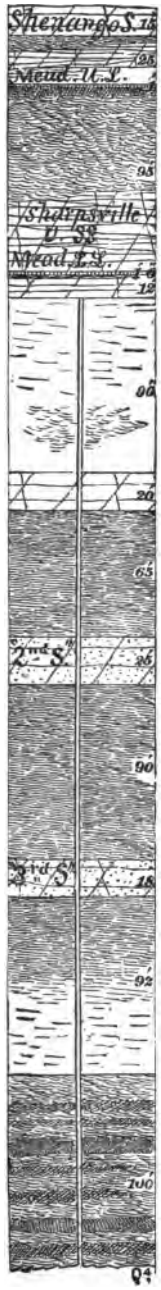
This township lies between the Pymatuning swamp and Conneaut lake, enclosing the latter, which was used as a feeder for the now abandoned Beaver and Erie canal.

Conneaut lake, however, lies partly in Summit township, being about four and a half miles long by one wide; its depth varying from a few feet to nearly 100′ in a few deep holes, and surrounded by low sloping banks of *Glacial drift.*—See Part I, pp. 20, 24, 35, 40, 41.

A high hill, about two miles southwest from Evansburg, rising to 1300′ A. T., takes in the *Shenango sandstone* over a large area.

The rock was here, at one time, quarried very extensively on the land of Mr. McDowell for the locks of the old canal.

41.



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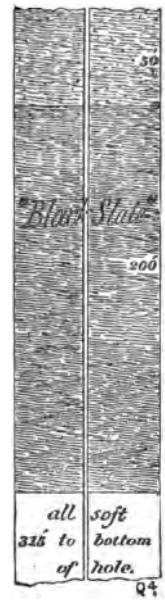

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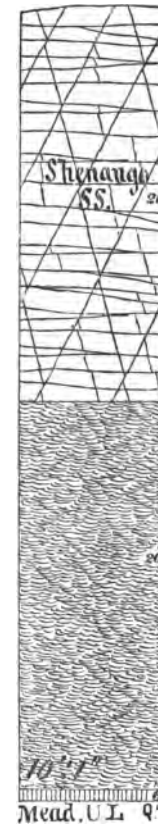

44.

It is a coarse massive light-brown rock, containing *fish remains* and *iron ore balls* in great quantity. Stone has been hauled from here to long distances in every direction.—Base of quarry rock, 1275′ A. T.

The *Orangeville shale* outcrops just south from Evansburg along the roadside, about 50′ above the level of the lake. It consists of fine-grained blue shales, in which are found occasional bands of sandstone from 1″ to 3″ thick.

An *oil well* was once drilled near Evansburg, but no record could be obtained, even from memory, and this is especially to be regretted, since a good record here would throw some light on the depth of the old lake bottom now filled with *Drift* deposits of unknown thickness.

On the eastern shore of the lake a broad level *terrace* is seen 50′ above the water.

Level of Conneaut lake,	(above tide),	1070′
Forks of road at S. Grigg's,	"	1080′
Next forks east,	"	1120′
Forks near J. Shout's,	"	1175′
" at A. Stratton's,	"	1110′
" near William Mellon's,	"	1115′
" " R. McDowell's,	"	1280′
" " J. C. Miller's,	"	1270′
" " A. Henry's,	"	1165′
" " W. T. Davis's,	"	1195′
Cross roads near E. Shellito's,	"	1265′
" " C. R. Stratton's,	"	1175′
Crossing of run east,	"	1150′
Cross roads near H. Burch's,	"	1070′
" " at Shermansville,	"	1100′

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13. *Summit, in Crawford county.*

This township lies north of Conneaut lake. Its eastern half drains southward into Conneaut lake and so through French creek into the Allegheny river; its northwestern quarter northward into Conneaut creek and Lake Erie; and its southwest quarter westward into Pymatuning swamp and the Shenango. Its former more extended area is described in Part 1, Chapter 3, in connection with the fresh-

water marl beds on the land of Mr. Almon Whiting north of Harmonsburg.—See page 40.

The following analysis of the marl was made for Mr. Whiting by the Chemist of the Department of Agriculture, Washington, D. C., Mr. Thos. Antisell, and placed at my disposal by Mr. Whiting:

Water and organic material,	4.00
Carbonate of Lime,	71.14
Sulphate of Lime and Magnesia,	3.25
Silica and traces of Alkali salt,	21.61

The following four analyses were made by Mr. McCreath in the Laboratory of the Survey at Harrisburg, and were taken by me from a copy sent to Mr. Whiting:

"No. 1. Burned in a close kiln at a white heat."
"No. 2. Same specimen when thoroughly and freshly burned."
"No. 3. Burned in open air at a red heat."
"No. 4. Raw marl." (Given already on page 42.)

	No. 1.	2.	3.	4.
Lime,	69.800	82.679	44.997	49 129
Magnesia,	1.405	1.943	1.163	0 839
Iron bi-sulphide,	. . .	. . .	.071	0.429
Oxide of iron,	1.850	1.176	0.860	0.170
Alumina,	0.810	1.119	0.808	0.020
Potash and soda,	0.322	0.445	0.538	0.116
Sulphuric acid,	0.841	1.162	0.877	0.222
Phosphoric "	0.042	0.058	0.062	0.023
Carbonic "	13.590	. . .	33.890	39.356
Organic matter,	1.010	. . . .	3.900	6.510
Silica,	7.940	10.978	11.541	1.052
Totals,	99.560	99.560	100.047	100.056

It will be perceived that Nos. 1, 2, and 3 contain much more silica than No. 4 which is doubtless to be accounted for by the fact that a very earthy variety of *peat* was used to a considerable extent in the calcination. The effect of this is seen in the specimen analyzed by Mr. Antisell.

A bed of impure peat 2′ to 3′ thick lies immediately on the marl; formed principally from the decomposition of the roots of several species of *Cyperus*.

The *peat* is still in process of formation, as can readily be seen where it has been dug through in the marl pits, revealing the roots and stems of grasses and sedges still penetrat-

ing the mass from top to bottom. A small stream oozes over the ground, and from it has been derived, during seasons of floods, the great amount of impurities that it contains in the shape of muddy sediment.

This impure *peat* is burned with the marl when intended as a fertilizer, the supposition of Mr. Whiting being that it very much enriches the same; but the analyses given render that theory extremely doubtful, to say the least, since by comparing the burned (Nos. 1, 2, 3) with the unburned marl (No. 4) it will be perceived that while the former have gained only slightly in the proportions of potash, soda and phosphoric acid, they have at the same time been loaded with over 10 per cent. of insoluble products, in the shape of Silica and Alumina, which can of course have no beneficial action on the soil, more than scattering over it so much sand.

The lime is valued for plastering purposes, and is hauled to a long distance into the surrounding country.

Oil well. About two miles west from the marl beds a boring was made for oil in 1861 on the land of Mr. Philip Brown, who gave me the following record of the same:

P. Brown's oil boring.

Gravel,	4′
Cussewago Sandstone, soft coarse yellowish,	30′
Slate and soapstone,	178′
Sandstone, coarse white, (*some gas,*)	20′

Elevation of well mouth (head waters of Conneaut creek) by barometer 1090′ A. T.

The *Cussewago Sandstone* is represented as quite soft and rotten, containing some pebbles. I know it to be the rock named because it comes to the surface at the right elevation (making due allowance for dip) a mile further to the north.

Gas but no oil came from the lower sandstone which is no doubt one of the *Venango Oil Sand group.* Mr. Brown supposed it the *Third Oil Sand*, but that cannot be, because the probable place of the *First Oil Sand* is at about 100′ down in the well; and therefore the well is not deep enough for the *Third.*

About one and a half miles north from this near the Catho-

lic church, a small run puts into Conneaut creek, and descending it from the top of the hill the following section was made: (Fig. 46.)

Catholic Church Section.

Sandstone, (*quarried,*)	10′
Concealed with occasional layers of flaggy sandstone,	80′
Cussewago Sandstone, (base 1030′ A. T.,)	30′
Blue Shale,	?

The top sandstone was once quarried quite extensively for the locks of the old canal, which passes along Conneaut creek at the foot of the hill. It lies in layers 1′ to 2′ thick; a bluish-gray rock; possibly representing the *Corry Sandstone.*

The *Cussewago Sandstone* has that peculiar lithology so unlike anything else in the series as to stamp it at once.

It is the same as the 30′ rock struck near the top of the boring on the land of Mr. Brown. It is here a very coarse greenish brown sandrock, the *upper* part of which is completely decomposed and makes a mere sand-bank along the stream. In the *lower* part many pebbles are seen, and the stratum is very rotten and incoherent throughout. See Part I, ch. 9, page 95.

Immediately below the base of the *Cussewago sandstone*, some fine blue shale is seen, and then everything is concealed to the level of Conneaut creek.

Barometric Elevations in Summit.

Cross-roads near Jas. Boyle's,	(above tide),	1260′
Forks near Adam Faust's,	"	1150′
" R. Kelley's,	"	1105′
" J. W. Greer's mill,	"	1100′
Forks next north,	"	1105′
Harmonsburg,	"	1110′
Level of run near cheese factory, east,	"	1105′
Forks near Sebastian Quigley's,	"	1180′
Cross-roads next east,	"	1200′
Forks near Henry Bright's,	"	1230
Cross-roads near W. Warden's,	"	1165′
" " Darius Smith's,	"	1205′
" " Geo. Sitler's,	"	1160′
" " Alex McGuire's,	"	1100′
" " Jas. McGuire's,	"	1200′

Cross-roads near Philip Brown's,	. . . . .	(above tide),	1120′
" " O. C. Denison's,	. . . . .	"	1205′
" " Silas Ford's,	. . . . .	"	1220′
" " Jas. Garwood's,	. . . . .	"	1240′
" " Catholic church,	. . . . .	"	1200′

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14. *Vernon, in Crawford County.*

This township lies between Conneaut lake and French creek; Watson's run crosses it from north to south, and Van Horn's run flows south through its eastern part, parallel with and into French creek, below Meadville. Cussewago creek makes the east half of its north line.

A high broad northwest-southeast ridge occupies its central portion. The northeast and southwest quarters are low and flat.

Conneaut Lake creek (the south line of the township) flows in a valley more than two miles, formerly an almost continuous marsh; but now to a considerable extent drained by the deepening of the channel of the creek by steam dredging. It is intended to continue this process on down to the mouth of the creek.

The *Shenango sandstone* is found on the highest parts of the central ridge; the *Venango oil measures* occupy French creek valley; but *Drift* covers the whole township, and rock exposures are quite rare.

At Meadville, opposite the Lower Iron Bridge, the hill rises quite abruptly, and here a ravine exhibits the following outcrops (Fig. 47):

Meadville Iron Bridge Section.

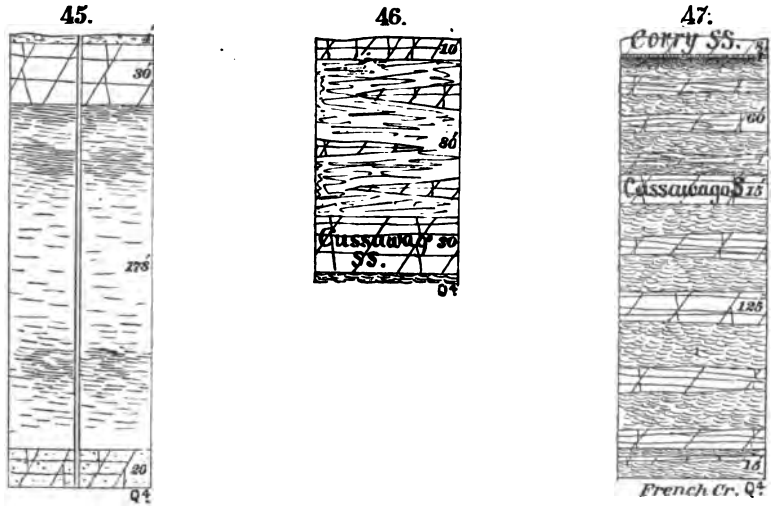
Corry Sandstone, somewhat massive,	8′
Cussewago Limestone,	1′
Shales and flaggy sandstones,	60′
Cussewago Sandstone,	15′
Shales and flaggy sandstones,	125′
Blue shales, with thin layers of sandstone to level of French creek,	15′

The *Corry sandstone* is partly quite massive, and large blocks of it are seen along the little stream; some of the blocks contain small pebbles; it is a light-yellow rock, quite

hard and durable, and was once quarried to some extent on the bluff above the old tan-house..

The (*Cussewago*) *limestone* seems to come in the series here at the same horizon as the lower limestone along Cussewago creek. It is quite hard, compact and breaks with glistening surfaces. Blocks of it scattered along the stream, are rounded on the angles.

The *Cussewago sandstone* is a very coarse loose rock of a greenish-brown color and an attempt was once made to



open a quarry in it just below where the *Corry* was quarried; but the rock proved so friable that nothing could be done with it.—Base, 125′ above the level of the R. R. at the depot in Meadville,=1205′ A. T.

Venango First oil sand?—A sandy stratum, 15′ to 20′ thick at the base of the 125′ shale was excavated for a wine cellar opposite the Dock street bridge. It lies about 450′ below the *Sharon Conglomerate.*

Many species of *Chemung shells* are seen on the slabs, among which are *Spirifera disjuncta*, *Productella Boydii*, *Pterinea*, *Sp.? Aviculopecten suborbicularis*, and others.

The blue shale, very argillaceous, is exposed along the road near Shryock's mill.

An *oil well* was bored just above the mill to a considerable depth by Mr. Shryock, but no oil of any consequence was obtained.

One and a half miles south from Meadville, where the road ascends the hill south from Van Horn's run, 2′ of the hard grayish top of the *Corry sandstone* is exposed (1215′ A. T.)

Orangeville shale, very argillaceous, and having thin layers of sandy material interstatified at every 3 to 5 feet, is seen overlying it.

Meadville limestone.—On the right bank of Van Horn's run, near the McMichael's school house, the outcrop of a quite silicious *limestone* 1′ thick is seen at 1325′ A. T.

Shenango sandstone blocks are scattered over the surface along the ridge to the west, near J. Keller's, at 1400′ A. T. The mother rock is not seen and is probably eroded from the hilltop, and may have had a considerable higher elevation.

*Barometric elevations.**

Elevation of Van Horn's run where pike crosses it south from Meadville,	(above tide,)	1095′
Forks of road near J. Kennedy's,	"	1265′
" " D. Reymore's,	"	1370′
" " P. Brown's,	"	1370′
" " D. Keep's,	"	1300′
Forks next south of "	"	1190′
" " west from last,	"	1140′
" near Trace's School House,	"	1090′
Crossing of Watson's run just south,	"	1080′
Forks near Andrew's Church,	"	1110′
" north from A. Brown's,	"	1115′
" next northwest,	"	1120′
" near J. F. Brown's,	"	1115′
" " J. I. Brown's,	"	1115′
" west from L. Trace's,	"	1145′
" near J. L. Beatty's,	"	1235′
" next east,	"	1200′
Cross roads near J. J. Beatty's,	"	1255′
" next east,	"	1235′
Forks near G. Kollabaugh's,	"	1335′
" P. Ouspaugh's,	"	1335′
" E. Schmallenberger's,	"	1315′
" G. Wallace's,	"	1375′

* Very closely checked.

Cross roads near H. Smith's,	(above tide),	1340′
Forks near J. Keller's,	"	1375′
" J. Curry's,	"	1390′
" Jacob Work's,	"	1150′
" Mrs. Keeber's,	"	1190′
" J. B. Palmer's,	"	1220′
Cross roads near A. Gibson's,	"	1200′

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15. *Mead, in Crawford county.*

This large township lies east of French creek and incloses the borough of Meadville, the county seat.

A table land occupies its middle, (north and south lying) belt, draining west into French creek, south and west into Little Sugar creek and north into Woodcock creek.

Another table land carries the east township line.

Between the two table lands lies the (north-south) buried valley of Little Sugar creek, described in Part I, p. 36.

French creek flows in a buried valley, now filled up to a depth of at least 300′; for, on Smith's land near the southern line of the township, iron pipes were driven through quicksands and bowlders 285′, without touching rock bottom. This pipe started about 20′ above the level of French creek, making the depth of the old valley beneath the present level of French creek at least 275′.

The section of the rocks in this township extends from a few feet above the *Sharon coal* down to the *Venango First oil sand horizon.*

The Sharon Conglomerate caps the ridge northeast of Meadville with very massive ledges, and a small stream descending from these highlands through the Greendale Cemetery to Mill run exposes a very good section as seen in the following: (Fig. 48.)

Meadville Section.

Sharon Conglomerate,	Quarry sandstone,	35′	45′
	Pebble rock,	10′	
Concealed but containing the massive *Venango Sandstone* just above its base			70′
Meadville	*Upper Shales*, blue, somewhat sandy,		15′
	Upper Limestone,		1′
	Lower Shales and flaggy sandstone,		35′

Sharpsville Upper Sandstone, flaggy, ... 60′
Meadville Lower Limestone, ... 2′
Sharpsville Lower Sandstone, flaggy, ... visible 10′
Concealed, but showing some exposures of the *Orangeville Shale*, near the base, ... 60′
Concealed to level of A. & G. W. R. R. at the Meadville depot, (1080′ A. T.,) . . . . . 170′
Concealed to level of French creek, (1062′ A. T.,) . . . . . 18′

The *Sharon Conglomerate* has been extensively quarried for a long time on the land of Dr. Carroll and others, north from Allegheny College on what is termed the College Hills. Only about 30′ has been quarried, the lower portion being somewhat pebbly, and the lowest 10′ a mere mass of *quartz pebbles*.

The upper, or quarry portion, is a dull gray sandstone; often tinged red, and sometimes buff; tolerably coarse; and some of the courses often containing a few pebbles. Some parts of the ledge show a great tendency to false-bedding.

The rock is quite durable, except when containing many pebbles, and then it is so coarse that the weather soon breaks it up and the rock crumbles away. This is shown in the coping stones of the M. E. Church which have already begun to decay.

The base of this deposit is a perfect mass of quartz pebbles, varying in size from a pea to a walnut, and even a hen's egg. Around the base of the hill, below the quarry, may be seen a regular bed of loose pebbles derived from the decay of the rock; the matrix holding the pebbles being a coarse bluish-gray (sometimes greenish-gray) sand. The rock crops out in a ledge along the stone road which leads up to the Carroll quarries.

The *Shenango sandstone* lowest layers are exposed along the run; and large blocks of it lie higher up on a steep bluff around the hill. In the lowest layers may be noticed some flat pebbles of quartz.

The *Meadville Upper Limestone*, named from this locality, is a hard silicious stratum, containing probably 60 per cent. of carbonate of lime; very fossiliferous; especially rich in *fish remains;* and holding many *shells* of mollusks and *pebbles* of shale and of dark fine-grained sandstone.

The *Sharpsville Upper Sandstone* is here, as nearly always elsewhere, a darkish gray rock, in layers of 6″ to 2′; quite hard, and often separated by thin layers of shale.

The *Meadville Lower Limestone*, finely exposed in the bed of the stream, makes a cascade. Large, angular blocks (with the edges rounded off) lie scattered along the bed of the stream for a considerable distance near the hydraulic ram which supplies the cemetery with water. The limestone rock is quite hard, and breaks with the peculiar glassy fracture so common to the calcareo-silicious deposits under the Conglomerate.

The base of the *Sharpsville Lower Sandstone* was not seen, but the topography along the stream would indicate that its thickness is probably not 10′, but 20′.

The *Orangeville Shale* is only exposed in two or three places, and that only for a few feet; but its characteristic structure and fossils readily isolate it from any other rock in our column at a single glance.

Barometric Heights.

Top of *Sharon Conglomerate*, ...	(above tide)	1548′
Top of *Upper Meadville Limestone*, ...	"	1418′
Top of *Lower Meadville Limestone*, ...	"	1322′
Railroad grade at Meadville depot, ...	"	1080′

Almost one mile east from Meadville, the following succession is seen in descending a small tributary of Mill run, on the land of Mr. S. E. Ellis (Fig. 49):

Ellis' Mill Run Section.

1.	*Shenango Sandstone*, ...	20′
2.	Shales, ...	30′
3.	*Meadville Upper Limestone*, ...	1′
4.	Shales and flaggy sandstone, ...	50′
5.	*Limestone*, [*Meadville Middle Limestone?*], ...	0′ 6″
6.	Sandstone, ...	25′
7.	*Meadville Lower Limestone*, ...	2′
8.	*Sharpsville Lower Sandstone*, ...	30′
9.	*Orangeville Shale*, seen, ...	40′
10.	Concealed to level of R. R. at Meadville Dépot (1080′ A. T., ...	163′

The *Shenango Sandstone* has here a very good development, and large blocks of it have tumbled from the cliffs

into the bed of the stream. It is a dark grayish-brown rock, and should be quarried for building purposes instead of the *Sharon Conglomerate*, which is worked so extensively at the Carroll quarries, one and a half miles to the northeast. It would make a much more durable structure than the latter, and is softer and more easily worked. It would certainly pay to open a quarry at this locality.

The underlying blue shale, generally quite soft, contains some thin siliceous layers.

The *Meadville Upper Limestone* contains an abundance of *fish remains* here, as well as many *shells*.

The interval between the *Upper* and *Lower Meadville Limestone* is here much smaller than usual, but the *decrease* in this is almost exactly counterbalanced by the *increase* in the thickness of the *Sharpsville Lower Sandstone*, so that the interval from the *Upper Meadville Limestone* to the top of the *Orangeville Shale* remains about as usual—107′.

The *Sharpsville Lower Sandstone* is more massive than common, some of the layers being 3′ or more thick.

The *Orangeville Shale*, dark-blue, and very argillaceous, is filled with *Lingulæ* and *Discinæ*. Its base is concealed; therefore its exact thickness is unknown, but probably not far from 60′.

The elevation here of the top of the *Lower Meadville Limestone* (1315′ A. T.) is almost exactly the same as in the preceding section near the cemetery.

Meadville oil well.—Further down Mill run, and within the borough limits of Meadville, an oil well was once drilled by the Meadville Oil and Gas Company, commencing only 5′ or 6′ above the bed of the run (70′ above French creek). No record was preserved, and all that can now be learned of it is what is imperfectly remembered by two or three parties who assisted in the drilling, or were connected with the company. These accounts vary so much that but little confidence can be placed in any of them; but all agree in the fact that *a large flow of gas*, with *some oil*, was obtained.

The depth at which this gas and oil was struck, however, is variously reported from 455′ to 700′. This disagreement

in the traditions shows that the true depth is not remembered by any one, and may have been much less even than 455′, which is quite probable on the supposition that the gas and oil came from the *Venango Third Oil Sand* or Le-Bœuf Conglomerate. For the proper place of this rock in this bore-hole is somewhere between 370′ and 400′.*

The oil is reported to have been dark green in color, and of rather heavy gravity.

Along the bed of Mill run, just opposite to where the oil well was bored, the thin flaggy rocks are filled with fossils, among which were seen *Aviculopecten sub-orbicularis*, *Spirifera disjuncta*, *Productella Boydii*, and many *encrinal stems* and fragments. Mr. Carll obtained some fine specimens here, and he first called my attention to the locality.

As we pass up Mill run its bed gradually rises to about 1230′ A. T., where it heads in a marsh, from which flows southward Little Sugar creek. This buried valley was described in Part I, Chapter 3.

Near the head of Mill run a strongly-smelling *sulphur spring* occurs at the roadside, on the land of Mr. Custead, at 1210′ A. T.

Near the southern line of this township, on the land of Mr. Smith, the following section was obtained in descending a steep ravine to French creek (Fig. 50:

Smith's Section.

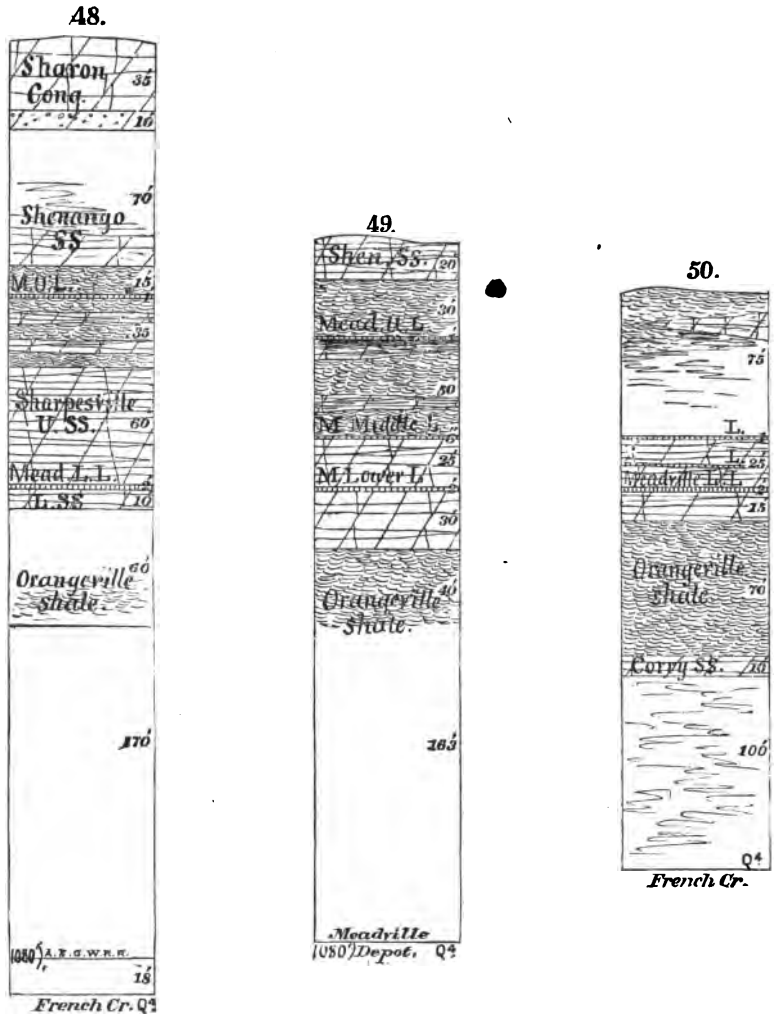
Shale, sandstone, and concealed,	75′
[*Meadville Middle?*] *Limestone*, very siliceous,	1′
Flaggy sandstone (one limestone band),	25′
Meadville Lower Limestone (1235′ A. T.),	2′
Sharpsville Lower Sandstone, flaggy,	15′
Orangeville Shale,	70′
Corry Sandstone, coarse, greenish-brown,	10′
Concealed to level of French creek,	100′

There seems to be an unusual amount of calcareous matter in the *Upper Sharpsville Sandstone* at this locality, since it contains two bands of *limestone*, very silicious, however, and *non-fossiliferous*.

* Such is the result of a calculation based upon the fact that the *Sharon Conglomerate* lies 380′ above the mouth of the well.

The *Meadville Lower Limestone* is more calcareous than those above it.

The *Orangeville Shale* is dark bluish-gray, quite soft, and



abounding in *Lingulæ*, as well as *Discinæ*. It contains a few bands of thin sandstone.

The *Corry Sandstone* is represented in the section by a

very coarse-grained, incoherent sandstone, of a greenish-brown color,—top 1150′ A. T.

Bore-holes in Drift.—On the bank of French creek, near where this section ends, on the land of J. Smith's heirs, two oil wells were attempted. First, an iron pipe was driven to a depth of 200′, where it got bent and had to be drawn. Another trial was made near the first hole, 20′ above the level of French creek; and there the loose Drift in the buried valley was penetrated to a depth of 285′, where the undertaking was abandoned. A great deal of quicksand is said to have been encountered, and the driving was very slow and difficult.

Almost three miles due east from Meadville, the surface rises to an elevation of 1580′ A. T.

The *Sharon coal*, on the land of Mr. A. Wright, seems to have a small patch left, judging only by the fact that in digging a well, after passing through 28′ of *Drift*, Mr. Wright came upon a loose bed of *coal*, broken and scattered through the material of the Drift as at Byhm's in E. Fairfield township; see p. 131 above. Here the water came, but Mr. Wright judged from the broken character of the bed, that it was about 2 feet thick. The coal burned very well, and a small piece of it which he showed me exhibited the *block* structure.

Shenango Sandstone.—About one-half mile east from Wright's and just north from Mead Corner's, a ledge of massive sandstone is seen extending around the hill. The base of the ledge is 160′ lower than Wright's *coal*. The rock is coarse, grayish-brown, and contains many streaks of pebbles. Large blocks of it lie scattered over the ground. The layers without pebbles, making an excellent building stone, have been quarried here.

One mile north from Mead Corner's on the land of Mr. G. McNamara a ravine coming down from the highlands west, exposes the following (Fig. 51):

McNamara's section.

Sharon Conglomerate,	40′
Concealed,	50′

Shenango Sandstone, very massive, ... 25′
Concealed, ... 25′
Shales, ... 5′
Meadville Upper Limestone, (1442′ A. T.,) . . . . . ½′
Shales, ... 30′
Limestone in three layers, (1412′ A. T.,) . . . . . 2′
Shales and concealed to level of road at 1330′ above tide, . . . 80′

The *Sharon Conglomerate* is seen along the Meadville road west from McNamara's near W. S. Chase's, forming a line of cliffs along the hillside; a grayish-white coarse sandstone, containing some pebbles.

The *Shenango Sandstone* making a perpendicular fall of 20′, very massive, and forming a line of cliffs around the head of the gorge, is a coarse buffish-brown rock, containing numerous *balls of iron ore.* The rock is visible for 25′, and is probably 35′ thick.

The *Meadville Upper Limestone* is here a mere mass of *fish and shell remains.* In fact, the matrix can scarcely be seen on account of the *innumerable scales* which cover the surface of the stratum.*

The *Meadville* [*Middle?*] *Limestone*, also filled with *fish* and *shell remains*, simulates in every respect the *Upper Limestone.* It comes in three layers, and contains many flat pebbles of shale.

The *Sharon Conglomerate* underlies all the country between McNamara's and Meadvillle, thus forming an elevated plateau, with the top of the rock only a few feet below the surface, where it is frequently struck by the farmers in digging their wells.

About one mile north from McNamara's a very deep ravine is cut down parallel with the road on the land of Mr. Chase, and in it the following succession is seen: (Fig. 52.)

Chase's section.

Bluish, sandy shales, ... 30′
Meadville Lower Limestone,† very hard, (1395 A. T.,) . . . . 1′
Shales and flaggy sandstone, ... 20′

* Here 1442′ A. T. and at Meadville 3 miles west, 1418′ A. T.—*Rate of rise eastward about 8′ to the mile.*

† I suppose this to be the *Lower Meadville Limestone* (1395′ A. T.,) because at McNamara's, only one mile south, the *Upper M. L.* is 1442′ A. T.

52.

Oil well.—About five miles southeast from Meadville, on the land of Mr. A. J. Preston a well was once bored for oil to a depth of 900′, commencing (1375′) 140′ below where the *Sharon coal* was found in a well at Mr. Boyle's house ¾ of a mile away.

A excellent *sand* (15′ to 20′) was struck at 625′ in which, I am told, a splendid oil show was obtained, but owing to some trouble with the contractor the well was never pumped. I saw some of the *sand drilling*. The pebbles were large, and the cementing matrix very soft and coarse. There were many fragments of jasper, and smoky quartz.

This region deserves thorough testing, for the indications point to a productive oil field of small extent.

A small vein of coal was found in digging a well on the land of Mr. Boyle's ¾ m. northwest from Preston's. Surface elevation 1530′ A. T. Coal in the well 1512′ A. T. Coal said to be 18″ thick and to burn well.

*Barometric elevations in Mead.**

Forks of road at northeast corner Huidekoper Pk., ...	(above tide,)	1155′
Forks near Unitarian College, .	"	1280′
Level of Mill run near W. H. McGaw's, ...	"	1180′
Forks southeast from J. A. Miller's, ...	"	1210′
" near Sulphur Springs on Mill run, ...	"	1210′
Forks next east, ...	(above tide),	1270′
" "	"	1415′
Fork near S. Boils's, ...	"	1520′
" " J. McNamara's, ...	"	1525′
" next southeast, ...	"	1310′
Where road crosses run a short distance south E.,	"	1260′

*Most of them carefully checked two or three times, so that they may be relied on as close approximations.

Forks near Mr. Cole's,	(above tide),	1310′
" next southeast near Cemetery,	"	1500′
" near S. Kiser's,	"	1360′
" " Mrs. Finney's,	"	1270′
Level of Little Sugar creek, east,	"	1200′
Forks near F. Brown's,	"	1300′
" " J. Duciet's,	"	1335′
Forks near J. Brawley's,	"	1400′
" " Frenchtown,	"	1375′
" next east,	"	1385′
" west from Frenchtown,	"	1350′
" near A. Galmish's,	"	1265′
" next west where road turns north,	"	1220′
Crossing of Little Sugar creek near P. Deviller's,	"	1215
Forks north from N. Brawley's,	"	1250′
" near R. K. Ewing's,	"	1260′
" " H. Brawley's,	"	1450′
" next northwest,	"	1345′
" near Mrs. Kightlinger's,	"	1320′
Cross roads at Town-House,	"	1450′
Forks near S. Lamlo's School-House,	"	1480′
" " J. Morrisey's,	"	1490′
" " G. Smith's,	"	1465′
" " G. W. Custead's,	"	1305′
" " S. S. Thurston's,	"	1370′
Cross roads at J. Lawson's,	"	1390′
" " J. Lane's,	"	1320′
Forks near Rufus Smith's,	"	1130′
" " D. S. Ellis's,	"	1230′
" next east at School House,	"	1410′
Summit near E. B. R. Sackett's,	"	1580′
Cross roads near J. Burns's,	"	1510′
Summit near A. Wright's,	"	1580′
Mead Corner's,	"	1320′
Forks next east,	"	1265′
Level of left Br. of Little Sugar creek, next east,	"	1225′
Level of right Br. of Little Sugar creek, next east,	"	1225′
Cross roads near S. Richard's,	"	1265′
Forks near L. Deremer's,	"	1285′
Level of Little Sugar creek, near L. S. Doane's,	"	1235′
Forks next west,	"	1260′
" near E. D. Mead's,	"	1270′
" " G. McNamara's,	"	1330′
" " H. Marker's,	"	1325′
Cross roads near Lorin Stein's,	"	1420′
Forks near H. A. Hatch's,	"	1470′
Forks near W. Clark's,	"	1440′
Valley between Marker's and Stein's,	"	1290′
Cross roads near J. F. Breed's,	"	1320′
Forks near A. William's,	"	1520′

Cross road near G. Reeves's,	(above tide),	1535′
J. Douglass, "Fine Points,"	"	1520′
Forks near A. Oak's,	"	1500′
Cross roads near C. Cullum's,	"	1515′
" next northwest,	"	1520′
Forks near T. Willson's,	"	1450′
" " H. Yocum's,	"	1380′

16. *Randolph, in Crawford county.*

This township lies directly east from Mead, and extends its southeast corner nearly to the Venango county line.

A large part of the southern and eastern portions of this area is covered with a wilderness of almost unbroken forest; and the land is partly swampy and partly elevated land of the *Conglomerate series*.

The west line ranges along the north-south plateau west of the buried valley in which Woodcock creek and Sugar creek west branch head together near Guy's Mills; as described in Part I.

East of this valley another north and south range of hills spread out between the two forks of Sugar creek.

The central valley is filled with a deep deposit of *Drift* and the rocks outcropping on the hills are everywhere scored by ice. The flat divide in the middle of the valley is about 1330′ A. T., and the hills to the east and west of the valley rise about 200′ above the level of the divide.

Voison's quarry.—In the southwestern corner of the township a massive white sandstone is seen capping a summit (1560′ A. T.,) where it has been quarried on the land of Mr. Voison, a bluff 30′ high around the hill. The rock is a hard tolerably coarse-grained sandstone with very few pebbles and may possibly represent one of the *Connoquenessing rocks*, being too high for the *Sharon Conglomerate*, and too low for the *Homewood Sandstone*. A large spring of water issues from beneath the exposure, and Mr. Voison reports that when the pit was sunk into which the spring pours many lumps of *coal* were found. There may be a coal bed here; but the lumps of coal may belong to the *Drift*.

About two miles northeast from this, and west from Sugar Lake P. O. a line of *sandstone bowlders* is seen along the road at 1325′ A. T. They must come from a very massive stratum, and have the appearance of the *Shenango Sandstone*, the place of which, here, ought to come at about 1350′ A. T.

At Randolph P. O., near the northern line of the township, some very high *knobs* occur, and one of these on the land of Mr. McCartney, 1650′ A. T. is capped with a stratum of massive coarse white sandstone, probably the same as Voison's rock, but 90′ higher, and about 5 miles further north. This would give a south dip of say 18′ per mile. The top of the rock here is scarred with *glacial striæ* (S. 35° E. Magnetic) some of them nearly an inch in depth.

Radel's Oil boring.—One mile east from Randolph P. O., near the northern line of the township, a well was once drilled by Mr. Radel, commencing near the level of Woodcock creek, (1300′ A. T.) with a drive-pipe of 63′ before striking rock bottom.

"At 200′ a *sand* (15′) was passed through," probably the *Venango First Oil Sand.*

"At 565′ a splendid looking *oil sand* was struck; very loose and coarse; which furnished considerable gas and light green oil, notwithstanding the fact that the hole was drilled *wet.* This oil rock was 45′ thick, all good sand except the lower 10′ to 15′ which was rather fine and close;" probably the *Venango Third Oil Sand;* since the base of *Sharon Conglomerate* about 175′ above well+565′=740′.

Ellison oil boring.—On the land of Mr. Ellison near this, another was drilled at the same level to a depth of 900′, but the *3rd sand* was only about 20′ thick in this. It is possible that a small area of productive oil territory may exist in this region, if it were properly developed, but of course nothing could be determined from these *wet holes.*

Gilbert's oil boring.—About two miles east from Guy's Mills a well was once drilled on the land of Mr. M. W. Gilbert, commencing at 1510′ A. T. No systematic record was preserved, but Mr. Gilbert remembers very confidently that "the drive pipe was 87′ through clay, sand, bowlders, &c.,

mostly clay.—At 300′ a nice *white sand* (12′ to 15′) was struck.—At about 750′ or 800′ a *sand* (8′ to 10′) was struck, in which some gas and oil was obtained.—Well 950′.—Stopped in a *soft red slate.*"

The sand at 800′ ought to be the *Venango Third;* because the base of the *Sharon Conglomerate* is about 50′ down the well: 800′±—50′=750′±.

Further east from this is a high ridge covered with blocks of *white sandstone;* 1600′ A. T.

Near Hatch's School House in the southeastern corner of this township the base of the *Sharon Conglomerate* is seen (1445′ A. T.) exposed along a small stream which here starts eastward toward Sugar creek east branch. The hills rise to a height of 100′ above the base of the rock, but no *coal* has ever been found in this Sharon coal bed horizon. The side-hills are covered with large blocks of massive *pebbly sandstone*, derived mostly from the *Sharon Conglomerate.*

*Barometric Elevations in Randolph.**

Forks of road near township line at J. Pardee's,	(above tide,)	1400′
Cross roads near H. T. Brawley's,	"	1380′
Crossing of Sugar Lake creek, east,	"	1300′
Forks next east,	"	1315′
" near A. Bentley's,	"	1320′
" at Sugar Lake P. O.,	"	1300′
Level of road near S. H. Adam's School House,	"	1545′
Cross roads at F. Jeanney's,	"	1470
Forks near W. M. Manning's,	"	1485′
" " H. Johnson's,	"	1525′
" " P. Bogardies',	"	1540′
" " T. Bogardies',	"	1540′
" " W. Oak's,	"	1480′
" " Hatch's School House,	"	1510′
" " C. A. Bogardies',	"	1440′
" " J. Brandon's,	"	1505′
Cross roads near W. Banister's,	"	1500′
Road at Monroe's School House,	"	1500′
Forks near P. Monroe's,	"	1435′
" " L. C. Mattison's,	"	1375′
" " C. Rodger's,	"	1420′
" " C. Barne's,	"	1465′
Cross roads near Vance's School House,	"	1500′
" " R. McMullen's,	"	1490′

* These may be relied upon as correct within a limit of 25 feet.

Elbow bend in road, east,	(above tide),	1550′
Forks near Owen's School House,	"	1525′
Cross roads near V. C. Richard's,	"	1500′
Forks near J. L. Barlow's,	"	1520′
" just north,	"	1530′
" near N. Seamon's,	"	1440′
" " G. W. Cutshall's,	"	1330′
Level of Woodcock creek just west,	"	1305′
Forks near School House, Sherman's,	"	1370′
Forks near S. S. Sikes's,	"	1385′
Level of Woodcock near the east,	"	1355′
Forks near W. A. Hyde's,	"	1340′
" " Dr. Ashley's, at Guy's Mills,	"	1350′
Cross roads near H. Terrell's,	"	1450′
" next west,	"	1385′
" next west,	"	1440′
Forks near G. Marts',	"	1420′
" " S. Jackletts',	"	1440′
" " J. A. McLaughlin's,	"	1500′
" " J. McCarty's,	"	1550′
Cross roads at Randolph P. O.,	"	1590′

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17. *Troy, in Crawford county.*

This township surrounds the head branches of Sugar creek and extends eastward to Oil creek and along the Venango county line.

Armstrong's oil well.—Near the southern line of Troy, on Sugar creek, a well was once bored on the land of Mr. Jno. Armstrong, commencing about 5′ above the level of the creek; 1260′ A. T.

The *Drift* is here 130′ deep, to rock bottom.

At 340′ a *sand* was struck and some dark *lubricating oil* obtained.

At 550′ another *sand* yielded some gas and a *green oil* in small quantity. Oil still flows from the well and is collected for lubricating purposes.

The *Sharon Conglomerate* horizon is about 200′ above the well; so the two *sands* found probably represent the *Venango Second and Third sands.*

About one mile north from this, on the land of Mr. Faunce the *Sharon Conglomerate* is seen making a line of cliffs around the hill on the right bank of Sugar creek; a

very massive white rock; and the hill-side covered with its great blocks; 1430′ A. T.

The hill rises to a considerable elevation above these cliffs; and its top is strewn with many blocks of a buffish-brown sandstone, of a rather loose texture, and pitted with hundreds of dark spots, or holes, in such a manner as to give it a *honey-combed* appearance.

They have evidently come from a stratum like that quarried high up in the hills at Franklin, showing the same physical peculiarities. It may be either *Connoquenessing* or even *Homewood.*

I do not know its elevation at Franklin and have only seen the pitted stones in the R. R. ballast.

Proper's oil boring.—Just across the creek from this on the land of Mr. A. G. Proper, a well was drilled in 1877, commencing at 1345′ A. T.

Mr. Proper gave me the following information concerning it: "The conductor hole was 9′ deep when a bluish slate rock was found.

"Oil was struck at 660′ in a rather close-grained pebbly sandstone 45′ thick. The hole filled up 300′ with oil, and three barrels were dipped out with the sand-pump; the oil dark-green, and pronounced of excellent quality. Some trouble arose with the contractors, who removed their engine, and the well was never pumped."

Just north from the mouth of the well a bold cliff of the *Shenango Sandstone* (30′ thick) extends around the hill; and large blocks are scattered over the surface; Top of rock, 40′ above well mouth; or, 1385′ A. T.

The base of the *Sharon Conglomerate* should come about 50′ above the top of this cliff-sandstone, so that the *45′ oil sand*, struck at the bottom of this well, must represent the *Venango Third Oil Sand*, being 750′ below the *Sharon Conglomerate.*

Winter's deep oil well.—About 20 rods east from the Proper well, another was commenced 20′ lower and sunk 1700′. This was known as Winter's well. Depth of *Drift* to rock floor, 60′.

At 640′ some oil and gas was obtained in a sand which had a total thickness of 62′.

At 1000′ another sand, 30′ thick, also gave some show of oil and gas.

Just west from Troy Center the *Shenango Sandstone* forms a conspicuous bluff; and immense blocks lie scattered over the hill. The rock has a buffish-white color, and contains a great many iron nodules; base 1410′ A. T.

Passing east from Troy Center the hill rises 130′ above the horizon of the *Shenango Sandstone* and takes in the *Sharon Conglomerate*, but no one has ever seen or heard of any *Sharon coal* above it.

From this point east to Oil creek, the surface has a general elevation of nearly 1600′ A. T., and consequently often rises above the level of the *Sharon Conglomerate* but no *Sharon coal* has ever been found in any wells or other exposures at the proper horizon.

Near the northeastern corner of the township, a steep hill rises abruptly on the western bank of Oil creek, and descending it along the road the following is seen: (Fig. 53.)

Shenango Sandstone,	25′
Concealed and shales,	180′
Corry Sandstone, (base 1325′ A. T.,)	10′
Shales and concealed to level of Oil creek,	85′

The *Shenango Sandstone* quite massive, makes a steep bluff around the hill (the strata often seen) from which huge masses have separated and slid down; reddish-brown in color, and contains iron nodules in great numbers.

The *Corry Sandstone*, well exposed along the road, is also seen in a cliff on the steep hillside. It has here the same peculiar aspect and buffish-white color which nearly always distinguish it from every other rock in the series. A large spring issues from beneath it, just below the road.

Orangeville Shale, blue and argillaceous as usual, outcrops 40′ above the cliffs.

The ash-gray shales below the sandstone are quite argillaceous, with occasional thin layers of sandstone.

Shriner's oil well.—Just west from the line of this section an oil well was bored, in 1878, by Mr. Shriner, at 1520′

A. T., to a depth of 550′; at 500′ a tolerably good *sand*, 40′ thick, but no oil.

Emery & Tateham's well.—Near this, another well was finished in May, 1879, on the land of Messrs. Emery & Tateham; 1525′ A. T.; oil at 500′=1025′ A. T. The well yielded 40 barrels in the first 24 hours; then water came in suddenly and drove the oil away; oil sand is 47′ thick; probably *Venango Second Sand*, since the well commences near the top of the *Shenango Sandstone.*

About one mile west from Shriner's, the outcrop of the *Shenango Sandstone* is seen at 1480′ A. T.

Above it, near the hilltop, on the land of Mr. Prather, is a steep bluff made by the *Sharon Conglomerate*, and pebbly masses are scattered about.

As we go further west along the northern line of this township, the surface gradually rises until just west from the cross-roads at Moorheads, it attains an elevation of 1750′ A. T., nearly the horizon of the Homewood Sandstone.

Many small bowlders of the peculiarly *pitted sandstone* lie still higher on the surface at Faunce's and at Franklin.

Barometric Elevations in Troy.

Forks of road near J. E. Reynold's (S.W. corner township,)	(above tide,)	1280′
Forks of road near P. Arnold's,	"	1255′
" " " J. McClelland's,	"	1285′
" " " Faunce's heirs,	"	1300′
" " " Eagle Pet. Comp. property,	"	1295′
Cross-roads near W. P. Morse's,	"	1320′
Forks next north,	"	1320′
Forks near Hayes' & Proper's mill,	"	1320′
Cross-roads in Troy Center,	"	1370′
Forks near J. Mercley's,	"	1520′
Cross-roads near J. H. Hawthorn's,	"	1525′
Level of run east,	"	1445′
Forks at D. J. Sterin's,	"	1570′
Surface at J. Reynold's,	"	1610′
Level of first run east,	"	1530′
Cross-roads near R. Reeser's,	"	1570′
" " A. Hancock's,	"	1590′
Level of Oil creek at road-crossing in northeastern part of township,	"	1240′
Cross-roads near F. Shriner's,	"	1570′
Forks at school-house next west,	"	1520′

Cross-road near T. Prather's,	(above tide),	1430′
Forks near F. Smith's,	"	1685′
Cross-roads at Moorhead's,	"	1730′
Summit just west,	"	1750′
Forks near J. Attenburg's,	"	1585′

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18. *Oil Creek, in Crawford County.*

This township occupies the southeast corner of Crawford county, on the Warren and Venango lines. Its southwest quarter is traversed by Oil creek, flowing southeast; Little Oil creek from the north, and Thompson's creek from the northeast, unite and flow into Oil creek at Hydetown. In the southeast corner, Pine creek comes west from Warren county into Oil creek at Titusville.

The remarkable history of oil production in Pennsylvania was here opened in 1859.

The old Drake well is just across the county line; but the first development spread northward from it to and around Titusville.

The *Third Oil Sand* lies here about 400′ below the surface.

The Watson well, the deepest (except one) ever bored in this country, was put down by Mr. Jonathan Watson, on the "Flats" of Pine, near the Warren county line, to 3500′, stopping, according to report, in the block shales of the Hamilton (Lower Devonian) formation. It will ever be a great source of regret to geologists that no reliable register was kept of the strata passed through in this well.

The rock strata, exposed in the township, include the *Sharon Conglomerate* above and the *Corry Sandstone* (*3rd Mt.*) *Sandstone* below.

Quarry.—About one mile below Titusville Dépot, and near the Venango line, the *Shenango Sandstone* has been quarried to a considerable extent; thickness, 25′; base, 230′ above Oil creek, or 1395′ A. T. The rock is a buffish-brown, tolerably coarse-grained sandstone, splits readily and looks as though it would stand the weather quite well.

Derricks.—Along the valley above this, and in the vicin-

ity of Titusville, a great many old derricks are standing as monuments of the former activity which prevailed here in the oil business. The wells have all ceased to yield in paying quantities, however, and have long been abandoned for new territory. It is possible, however, that the time may come when all this once productive territory may be worked over again, and produce oil in paying quantities.

Drift oil.—East from Titusville about two miles, on what is known as Watson's Flats, in April, 1877, a common spring suddenly began to flow oil at the rate of several barrels daily. A great many shallow wells were dug in the valley Drift, coupled together and pumped, and yielded at a rough calculation 10,000 or 12,000 barrels of oil, all told, before October, when the pool was exhausted. A complete account of this curious episode in the History of Petroleum will be found in Report of Progress I.I.I, Oil Regions. Carll, 1880, pages 422–429. It is unnecessary to repeat in this report the descriptions of the oil wells, &c., around Titusville, which fill Mr. Carll's Reports I, I.I, and I.I.I, on the Oil Region of Pennsylvania. The atlas to Report I.I.I contains carefully constructed sections from many well records.

A knob about 2½ miles northeast from Titusville, rising to 1600′ A. T., is topped by a bed of massive, pebbly sandstone (probably *Sharon Conglomerate*), which shows in place above the road on the land of Mr. Henderson; large blocks also strew the surface.

About 1½ miles further southwest the *Sharon Conglomerate* outcrops at 1525′ A. T.

Blocks of coarse reddish-brown sandstone, filled with *fish remains* (*Shenango Sandstone*), strew the surface 60′ lower=1465′ A. T.

Along the road which leads directly north from Titusville the outcrop of the *Shenango Sandstone* is seen on the land of Mr. Watson:—*top*, 1505′ A. T.

A band of iron ore, 6″ thick, containing many fossil shells in a very imperfect condition, lies 4′ above the top of the sandstone; or, 1509′ A. T.

Just north from this the road passes over the *Summit* (1555′), but no traces of the *Sharon Conglomerate* appear.

Passing further north and descending the hill to Kerr's mills, on Thompson's run, the following succession in seen (Fig. 54):

Kerr's Mills Section.

Shenango Sandstone (¼ m. S. of the Mill),	?
Concealed, with occasional outcrop of flaggy sandstone,	150′
Orangeville Shale (on road), blue, clayey,	15′
Flaggy sandstone and concealed,	30′
Corry Sandstone, massive (*base* 1300′ A. T.),	15′
Shales to level of run below mill-dam,	10′

The *Corry Sandstone* forms a cliff at the mill, just below and opposite the dam; a close, fine-grained, quite hard, light-yellowish-brown rock.

The interval between the base of *Corry SS.* and the base of *Shenango SS.* here is about 210′; because, north from Thompson's run, the base of the *Shenango* is seen at 1520′; so, 1520′—1300′ (base of *Corry*)=220′. Allow 10′ for rise northward, interval=210′.

North from this, the summit surface near the northern line of the township, reaches the proper horizon for at least the basal portion of the *Sharon Conglomerate*, viz: 1600′ A. T.

In the western portion of the township the following rocks are seen in descending the steep hill from M. J. Loomy's to Hydetown (Oil Creek village), (Fig. 55):

Hydetown Section.

Sharon Conglomerate (*base*, 1550′ A. T.),	?
Concealed,	55′
Shenango Sandstone (*base*, 1465′ A. T.),	30′
Concealed to level of Oil creek,	235′

Many blocks of the *Sharon Conglomerate*, a coarse, pebbly, white sandstone, are seen scattered over the surface.

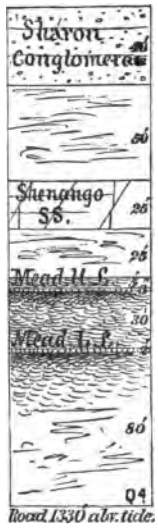
The *Shenango Sandstone* forms a steep bluff along the hill, and is seen outcropping in cliffs in many places. It is a coarse brown rock, and contains few pebbles.

At Hydetown several *oil wells* have been put down, and some *heavy oil* found in all of them, at 355′ below the level

of Oil creek, or (see preceding section) 675′ below the *Sharon Conglomerate* (*2and Mountain Sand*). The oil must come from the *Venango Second Oil Sand;* for, 750′ is the proper interval for the *Third.*

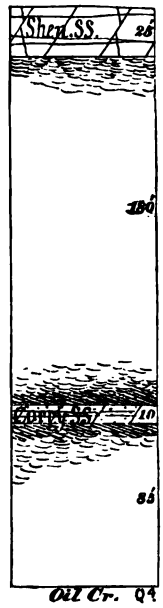
McNamara's.

51.



Oil Cr. Sect.

53.



Kerr's Mill Sect.

54.

The Ridgeway well, near and 5′ above the level of Oil creek; drive-pipe 20′. Heavy lubricating oil is still got from 360′; but the well never paid.

A boring was started at 6′ above Oil creek level, on the Reed estate, just above Hydetown, and abandoned when 190′ of pipe was driven without finding bottom rock. This shows the great depth of the old buried channel. Oil creek does not follow its old course exactly, for at Mr. Ridgway's, only one mile below Reed's, bottom rock is struck at 20′.

Many accurately leveled elevations have been given in this township in the Reports of Mr. Carll to which the reader is referred.

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19. *Rome, in Crawford county.*

This township lies between Oil creek and the Warren county line. The two branches of Oil creek unite at Centerville. Little Oil creek and Thomson's run head in this township and flow south.

Broad reaches of low land border both sides of the east and west branches of Oil creek, because they flow over planes of *Drift*, filling up deeply buried ancient valleys.

The eastern portion of the township is an elevated barren region; often swampy; some of the highest parts catching small patches of the *Sharon Conglomerate;* the *Shenango Sandstone* underlying a large area.

Half a mile north of the southern line, Mr. Matteson, in digging a well, passed 24′ into the *Shenango Sandstone.* The well commences at 1560′ A. T. which must be near the top of the stratum. The hill rises, west from this, 60′ higher without a trace of the *Sharon Conglomerate*, probably therefore eroded.

West of McLaughlin's run a high tongue of land catches a considerable area of the *Shenango Sandstone.* Descending toward Centreville, the *base* of the *Corry Sandstone* is seen near Mr. C. Barber s (a large spring issuing beneath it) at 1420′ A. T.

At Centerville the level of Oil creek opposite the R. R. station is 1275′ A. T.

The base of the *Corry Sandstone* here is 150′ higher,= 1425′ A. T.

The horizon of the *Venango First Oil Sand* here should be just below creek level.

Kinney borings.—One mile above Centerville some *oil wells* were drilled on the land of Mr. Kinney, but *no oil* obtained in paying quantity. One drive pipe, 90′; another, near it, 100′; mouth of first well 10′ above creek level.

A boring was commenced half a mile above Centerville, and abandoned 15′ above Oil creek, when 100′ of pipe had been driven without bottom.

Centreville boring.—Messrs. Nobles and Linsey drilled a well to a depth of 200′ within the borough of Centerville, but no oil was obtained. The amount of drier-pipe used in this well could not be learned, though one of the operators thought it between 40′ and 50′.

Barometric elevations in Rome.

Five points forks at Putman's store, ...	(above tide,)	1625′
Forks at W. Wright's, ...	"	1620′
Cross roads near A. Matterson's, ...	"	1630′
Forks near R. P. Randall's, ...	"	1615′
Summit near C. Hilliker's, ...	"	1700′
Forks near A. Rick's, ...	"	1600′
Forks near E. Lafferty's, ...	"	1545′
Level of Oil creek at Centerville, ...	"	1275′

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20. *Steuben, in Crawford county.*

This lies west of Oil creek and Rome township, and north of Troy. Oil creek passes through its eastern part, draining its central area. Muddy creek heads in its western part and flows north and then west into French creek. Sugar creek heads at Townville in the southwest corner and flows southward.

There is scarcely any perceptible divide between Muddy creek and Sugar creek, the lowest point at Townville being 1445′ A. T. Hills 200′ high border on each side this buried valley, by which Mr. Carll carries the pre-glacial Sugar creek into the ancient bed of French creek.

About one mile east from Tryonville the *Shenango Sandstone* is caught in the hill near the eastern line of the township on the land of the Jeremiah Tryon ; it is there quite massive and large blocks of the rock lie strewn over the surface. *Its base* lies 310′ above the level of Oil creek at Tryonville, or 1570′ A. T.

East of this the surface rises 60′ higher, but no fragments of the *Sharon Conglomerate* are seen.

A boring just below the bridge at Tryonville 10′ above the level of the creek, had a drive pipe to rock, 160′. Well mouth 1270′ A. T.

Another boring, near the old Hotel, 50′ higher than this last well (1320′ A. T.) drove about as far through the *Drift* (160′.) Depth of well 900′; no oil of any consequence.

Another well, one mile above Tryonville, on the land of Mr. Atcheson, 60 rods east from the creek, 600′ deep, yielded a small quantity of oil.

Another boring, about two miles below Tryonville, on the Preston farm, 10′ above the creek, had 200′ of drive pipe before bed rock was struck.

Another boring was made by Mr. Gray just west of the last who reported rock bottom reached at 160′, but the well was abandoned then.

In the *Limestone well*, near the hill, and a considerable distance from the center of the valley, rock bottom was struck at only 14′. Oil at 160′; and in very small quantity at some greater depth.

Another well, a short distance below the *Limestone well*, was drilled to a depth of 1000′, by the N. Y. Petroleum Company, and some oil obtained; but no one knows at what depth. This well still flows oil in small quantities, though it never was a "producing" well.

About 2½ miles west from Tryonville and ¼ mile east from the cross roads the *Shenango Sandstone* comes into the hilltop, and is seen along the road; many blocks of sandstone are scattered over the hilltop; *base*, 1600′ A. T.

Corry Sandstone.—Descending the hill east from this, we come down to the outcrop of a tolerably massive yellowish white sandstone, 200′ below where the base of the *Shenango Sandstone* was last seen.

One mile and a half north from the cross roads at Cornell's, a yellowish white sandstone is seen (at 1390′ A. T.) which is also the *Corry Sandstone.*

Orangeville Shale, quite blue and soft, is exposed for 35′, and concealed for 20′, on top of the *Corry* sandstone; top 1445′ A. T.

West from this one half mile, at the forks of the road

near Mr. A. Wheelock's, the *Orangeville Shale* is exposed for some distance along the road, at 1440′ A. T.

A flaggy sandstone (probably *Sharpsville*) is exposed at 1485′ A. T.

An oil boring, just southwest from Townville, on the land of Mrs. Phillips', went down 1200′, but no sands of any importance were found, except one fine-grained and gray at 700′, and it yielded nothing but gas.

About half a mile east from Townville, and near the southern line of the township, the *Shenango Sandstone* is finely exposed in the cliffs of a ravine below the road; very massive; containing *fish remains* and fragments of a plant much resembling *Lepidodendron Gaspianum* in great quantity; 30′ thick; base, 1570′ A. T.

South of this the hills rise more than 200′ above the *Shenango Sandstone*, and should catch the *Conglomerate coals*.

Fragments of the *pitted sandstone* are here seen scattered about the surface.

Barometric Elevations in Steuben.

Five Forks, one mile east from Tryonville, . .	(above tide,)	1625′
Level of Oil creek at Tryonville.	"	1260′
Forks just west at M. Bougher's, ...	"	1360′
" at Clapville, ...	"	1310′
" near John Waid's, ...	"	1500′
Cross-roads near Jas. Cornell's, ...	"	1615′
Forks next north (1½ miles), ...	"	1410′
" " southwest (½ mile), ...	"	1425′
" " "	"	1440′
Cross-roads near O. Phillip's, ...	"	1390′
Level of Muddy creek, opposite, ...	"	1375′
Level of road at cemetery, north from Townville,	"	1490′
Level of Muddy creek, just west from cemetery,	"	1435′
Cross-roads at upper end of Townsville, ...	"	1520′
Main cross-roads in Townville, ...	"	1445′

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21. *Athens, in Crawford County.*

This township lies between Oil creek and Muddy creek, and is almost wholly drained westward. Its surface is quite varied; rising to 1600′ A. T. along the central and northern

portions; and falling off to 1200′ A. T. in the broad low valley of Muddy creek.

One mile west from Centerville the outcrop of the *Corry Sandstone* is seen along the road near Mr. Warren Saunders'. Its base, visible at the spring near the watering-trough, is 1425′ A. T.

One mile west from this, at the forks of road near Wm. Saunders', we come to the summit of a broad flat ridge, capped with the *Shenango Sandstone;* base, 1625′ A. T.

As we go south from this along the ridge road, a great many blocks of the *Shenango sand* are seen; and at the cross-roads, near Mr. Palm's, a conspicuous bluff has its top at 1630′, and its base at 1600′ A. T.

Descending the hill west from this toward the valley of Muddy creek, we come to the outcrop of a massive sandstone (*Corry*), buffish-white, and tolerably fine-grained; 1400′ A. T.

Drift.—The valley of Muddy creek, in the vicinity of Little Cooly is filled with detritus to an unknown depth, and *quicksand* is found in all the wells, making it quite troublesome to dig them.

Near the northern line of the township, and just east from the school-house at J. D. Minnis', an outcrop of the *Orangeville shale* is seen along the road; it contains many *Lingulæ.*—1520′ A. T.

Red shale (5′) is exposed below this at 1510′ A. T.

Yellowish-white (*Corry*) *sandstone* makes a bluff around the hill, at 1485′ A. T., just east from this.

A *limestone* (*Meadville Lower?*) 1′ thick, with flaggy sandstone above it, and the *Orangeville shale* below it, is seen at the roadside, at 1525′ A. T.

East from this the surface rises to 1600′ at the forks of the road near Mr. Clark's, and descending from there, east, to Riceville, at the northern edge of the township, the following section is seen (Fig. 56):

Riceville Section.

Sandy shales and sandstone,	40′
(*Meadville Lower?*) *limestone*, siliceous,	1′
Sandy shales and concealed (*Sharpsville*),	45′

Limestone bed (with many *Lingula melia*),	0′ 8″
Sandstone, flaggy,	visible, 10′
Concealed (*Orangeville*),	35′
Corry sandstone, massive,	10′
Sandstone, flaggy,	50′
Shales,	10′
Sandstone, flaggy, exposed,	25′

As this section begins at 1600′ A. T., and as about 3½ miles due south from here the *Shenango sandstone* (base) is at 1600′ A. T., a northward rise of *20′ per mile* would put it at Riceville at 1670′ A. T., or 110′ above our limestone, which is about right for the *Meadville Lower Limestone.* Moreover, the *Corry sandstone* (top), 3½ miles south, is at 1400′ A. T., and at Riceville 1468′ A. T.; giving just about the required rate of dip.

The *Corry sandstone* is seen outcropping in the road near Mr. Rice's; and just around in the field to the north, very large blocks of it lie scattered over the ground. It is tolerably fine-grained, but some parts of it contain a few small pebbles. It is a buffish-gray rock, with blotches of red from iron stains.

Careful Barometric Levels in Athens.

Forks at W. Winter's (west from Canterville),	(above tide),	1385′
" near Warren Saunders',	"	1410′
" " Wm. Saunders',	"	1620′
Cross-roads near S. Palm's,	"	1630′
" " E. Hall's,	"	1370′
Level of branch of Muddy creek, just west,	"	1315′
" Potash creek next west,	"	1285′
Forks north from B. Pennell's,	"	1300′
Cross roads at school-house, near Jos. Drake's,	"	1555′
Forks near J. Free's,	"	1480′
Level of Muddy creek at crossing, ¼ mile above Little Cooley,	"	1200′
Forks just opposite.	"	1220′
Level of hotel in Little Cooley,	"	1220′
" Muddy creek, opposite Little Cooley,	"	1190′
Forks of road near M. Smith's,	"	1250′
" " " D. Osburn's,	"	1270′
" " " C. Bancroft's,	"	1500′
" " " E. Stratton's,	"	1605′
Cross roads near Powers' School-House,	"	1580′
Forks near A. Clark's,	"	1600′
" " M. Merchant's,	"	1595′

22. *Richmond, in Crawford county.*

This nearly square township lies between Muddy creek, flowing northwest across its northeast corner, and Woodcock creek bending west through its southwest corner. Its surface is quite irregular; a high broad dividing ridge extending from its northwest to its southeast corner; covered in many places with massive layers of the *Conglomerate series*, and toward its more northern extension with the *Shenango sandstone.*

A high knob on this divide, rising near the southern line of the township and about 2 miles west from its eastern line, is capped with a beautiful *white building stone*, which has been quarried at Southwick's to some extent. Thirty feet of it is exposed in a cliff just below the top of the ridge; top of exposure 1650′ A. T.

I am disposed (with some doubt however) to identify it with the *Upper Connoquenessing sandstone* of Voison's quarry in Randolph township at 1560′ A. T. (which see above) as its top is 200′ above the top of the *Shenango sandstone* at Mr. Washington Shorts', half a mile west.

The *Shenango sandstone* has been quarried in a ravine on the land of Mr. Shorts, (200′ below the top of the *white sandstone* at Southwick's.) It splits and dresses well, making a good building stone; and contains *iron nodules* as well as *fish remains.*

Sharon Conglomerate?—Mr. Shorts states that about midway between his (*Shenango SS.*) quarry and Southwick's white rock quarry there is a conglomerate with pebbles from the size of a pea up to a walnut.

In the hollow just west from Mr. Shorts' the outcrop of the *Meadville Upper Limestone* is seen (260′ below the top of the white sandstone at Southwick's) at 1390′ A. T.

An old oil well, in Woodcock valley just west from this on the land of Mr. Sanderson commenced at 1300′ A. T. and went down 900′ (to 400′ A. T.;) some oil and a considerable quantity of gas were obtained, but nothing definite could be learned of the depth from which they came.

Northwest from this along the elevated ridge previously mentioned, large blocks of white pebbly sandstone are frequently seen.

Near the northwestern corner of the township the *Shenango sandstone* forms the surface rock ; and caps the summits, in a long ledge of cliffs, on the lands of Mr. Biter and others ; thickness, 25′; top, 1645′ A. T.

The surface here is strewn with large masses of the rock which have broken away from the principal bed, which has been quarried to a small extent and makes a good building stone. Mr. Biter's wells passed through 12′ of the rock. Numerous *iron nodules* are seen enclosed in the coarse brown sand of which the rock is composed.

Meadville blue shales are exposed in a ravine, 30′ under the cliff rock.

Orangeville shale is exposed a short distance north from Mr. Biter's at the roadside ; it is quite blue (weathers to a rusty red) and about 10′ of it is seen, at 1475′ A. T.

In descending from Mr. Biter's past the cross-roads at Mr. G. Hutchinson's the following exposures are seen : (Fig. 57.)

Biter's section.

Shenango Sandstone,	25′
Flaggy sandstone and concealed,	155′
Orangeville Shale,	exposed for 50′
(*Corry*) Sandstone somewhat massive at top and flaggy below,	75′

The soft bluish *Orangeville shale* contains much disseminated iron and consequently weathers to a rusty red. Many *Lingulæ* and *Discinæ* are seen in it. Part of the concealed interval (say 25′) above is also probably occupied by this shale.

The massive portion of the *Corry sandstone* is only 5′ or 6′ thick ; but shows its characteristic buffish white color and peculiar texture.

Barometric elevations in Richmond.

Forks of road near			S. Marsh's,	(above tide,)	1300′
"	"	"	G. A. Bougher's,	"	1240′
"	"	"	M. Cole's,	"	1250′
"	"	"	S. Sybrant's,	"	1450′

Cross roads near E. Jinney's,	(above tide),	1570′
" at New Richmond,	"	1370′
Forks near C. Smith's,	"	1450′
" " M. Hunt's,	"	1420′
Cross roads at Lyon's Hollow P. O.,	"	1280′
Forks near Mrs. M. Willey's,	"	1300′
" " T. J. Short's,	"	1410′
" next east,	"	1480′
Cross roads near Wm. Gray's,	"	1570′
" " Riley Carpenter's,	"	1545′
Forks near Charles Winston's,	"	1480′
Cross roads at E. Kingsley's,	"	1500′
" " F. Sayer's,	"	1480′
Forks near E. J. Child's,	"	1410′
" " J. McFadden's,	"	1410′
" " I. Deland's,	"	1410′
Cross roads near H. Kelley's,	"	1220′
Level of Muddy creek near G. Smith's,	"	1180′
" " " J. Sweet's,	"	1160′
Forks near J. Gray's,	"	1200′
Cross roads near T. H. Miles's,	"	1220′
Forks near S. W. Osgood's,	"	1240′
" " Lyman Clark's,	"	1320′
" " R. A. Hume's,	"	1370′
" at D. S. Mackey's,	"	1435′
" near J. Wilkinson's,	"	1580′
Cross roads near G. Hutchinson's,	"	1640′
" " Buel Pinney's,	"	1380′
Forks near Jos. Buel's,	"	1435′
Cross roads near H. Swift's,	"	1555′

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23. *Woodcock, in Crawford county.*

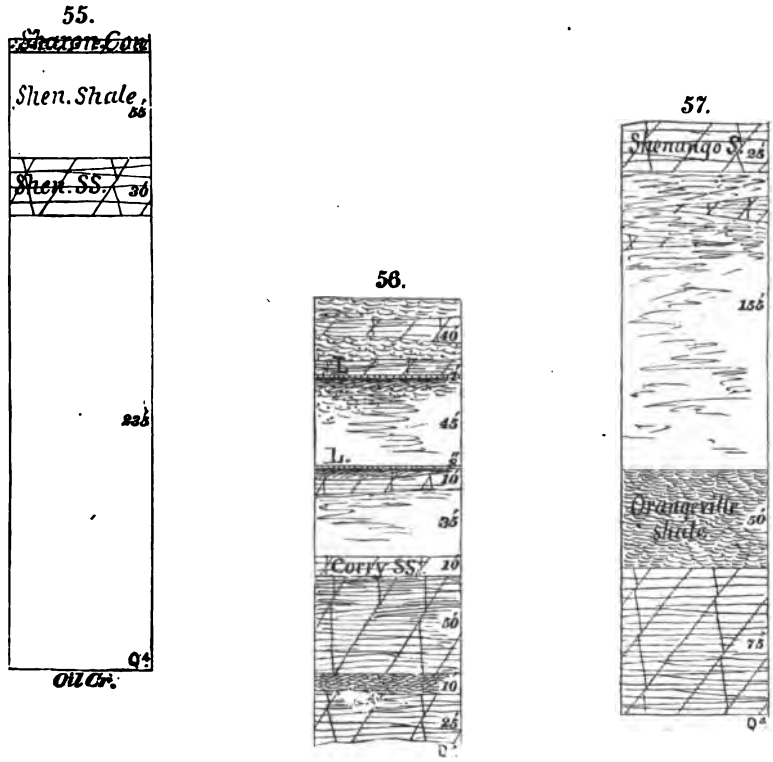
This township lies east of French creek above Meadville; and Woodcock creek flows through it.

Its rock section extends from the middle of the *Cuyahoga shale* on the hills down to the *Venango Group* seen only along French creek. The hills are all comparatively low; none of them rising higher than 1450′ A. T., except in the northwest corner.

In a ravine just east from Saegertown are exposed 70′ of rocks (base 1165′ A. T.) the lower layers (10′) being of a rotten, reddish-brown sandstone in which are many *Crinoidal fragments*, as well as *shells* of *Chemung* type. Above these layers are flaggy sandstones; and at the top is a

coarse *black, friable sandstone* (possibly the *Cussewago sandstone*, judging by its texture) of which 2′ only is exposed along the road, at 1230′ A. T.

West from this at Ryan's cross-roads near the center of the township, 10′ of the *Orangeville shale* very argillaceous and weathering reddish is seen at 1395′ (top) A. T.



Near Mr. John Clark's, 1½ miles north from Ryan's, 20′ of the *Orangeville shale* is seen along the road. How much more of this shale may be present cannot be known, since the measures both above and below are entirely concealed by débris; but the bottom of the exposed 20′ must be nearly the base of the *Orangeville shale*; because, just east from this, on the land of Mr. Humes, and only 10′ lower down the *Corry sandstone* is quarried, to a considerable extent,

as a tolerably massive buffish-white sandstone. The uppermost layers only are taken out. The top of the stratum has an elevation of 1375′.

The bottom of the *shale exposure* is at 1385′ A. T.

The top of the *Corry sandstone* is at 1375′ A. T.

A bore hole near Woodcock Center, went down 600′ or 700′; but nothing reliable could be learned concerning it, except that a slight show of oil was obtained at a depth of somewhere between 200′ and 300′.

About two miles above Sagertown a deep cutting occurs along the A. & G. W. R. R. and passing along it north from the bridge across French creek, the following succession is seen in the descending order: (Fig. 58.)

Railroad Section.

Sandstone, somewhat massive, . . . (*Venango First Sand,*)	25′
Shales, olive, interstratified with reddish sandy layers 4′ to 6″ thick,	20′
Shale, olive, very fine grained,	25′
Sandstone, flaggy,	10′
Concealed to level of French creek,	25′

The Sandstone at the top of the cut forms a cliff along the creek, in layers 2′ to 3′ thick, containing many *Chemung fossils.*—Base 1180′ A. T.

This is the same stratum the base of which is seen at the level of the A. & G. W. Railroad opposite Meadville. It is well exposed in a ravine at the upper end of the cut; and here I found in it *Productus Boydii*, *Spirifera disjuncta*, *Streptorhynchus Chemungensis* and other Chemung forms which I could not identify.

The upper olive shale, which contains, at intervals of 2′ to 3′, thin layers of dark brownish red sandstone, is in that respect quite unlike the lower shale, which is very fine-grained and destitute of sandy layers.

Near the southern line of the township, where the Meadville road crosses a small stream on the land of Mr. Peiffer, the following exposure is seen: (Fig. 59.)

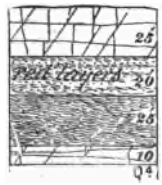
Pfeiffer's Section.

Sharpsville Sandstone (flags, 6″ to 1″),	20′
Orangeville Shale,	50′
Corry Sandstone,	20′

The blue, fine-grained flags are only the bottom part of the *Sharpsville sandstone.*

The *Orangeville Shale* is well exposed along the roadside as fine blue shales, with very little sandy material; the whole weathering to a reddish-brown on exposure; and containing many *Lingulæ* and *Discinæ.*

58.



59.

The *Corry Sandstone* here has its usual peculiar buffish hue; is somewhat massive, in layers 1′ to 2′ thick; and its top lies 1290′ A. T.

Barometric Elevations in Woodcock.

Cross-roads in Blooming Valley, ...	(above tide),	1290′
Forks of road first northeast, ...	"	1350′
Cross-roads northwest from Blooming Valley, near James Smith's, ...	"	1230′
Level of Woodcock creek, near Elizabeth Deney's,	"	1210′
Forks near Mary Kiser's, ...	"	1360′
" R. S. Waid's, ...	"	1380′
" E. Wootring's, ...	"	1270′
Forks next southwest, ...	"	1300′
Level of run just south, ...	"	1270′
" Woodcock creek, near A. Carringer's, .	"	1150′
Fork near A. Carpenter's, ...	"	1150′
" Wm. Long's, ...	"	1130′
" Fountain House Hotel, ...	"	1120′
" Crawford County Home, ...	"	1115′
Cross-roads near P. B. Detrick's, ...	"	1410′
Forks near Preston Cole's, ...	"	1350′
Cross-roads near D. G. Cole's, at School-House, .	"	1230′
Forks near W. Stewart's, at Town-House, . . .	"	1365′
" H. Bossard's, ...	"	1340′
Cross-roads near W. S. Ryan's, ...	"	1395′
Forks near Henry Norris', ...	"	1445′
" Wm. Wycoff's, ...	"	1335′
" Nancy Swift's, ...	"	1365′
" J. D. Hume's, ...	"	1385′
" T. A. Hume's, ...	"	1400′
" J. Coats', ...	"	1315′

Forks next south,	(above tide),	1305′
Level of run just east,	"	1280′
Fork near Legrand Smith's,	"	1570′
" D. O. Sausor's,	"	1360′
" Elizabeth Lang's,	"	1330′
" J. W. Lang's,	"	1300′
" J. C. Wales',	"	1280′
Woodcock Village,	"	1200′
Level of road at Mill, near mouth of Gravel run,	"	1120′
" Gravel run, at same point,	"	1110′
" French creek here,	"	1105′
Forks at William George's,	"	1180′

24. *Hayfield, in Crawford county.*

This township lies on the west side of French creek above Meadville, and is cut into two unequal portions by Cussewago creek, flowing southward into French creek at Meadville.

There is a broad highland between French creek and Cussewago creek with abrupt slopes descending to each.

On the west side of the Cussewago valley the hillsides rise quite abruptly and some fine sections are exposed; the creek itself meandering from side to side, along a Drift plain, over a deeply buried ancient channel, with no perceptable fall, through dismal swamps and a wilderness of vegetation.

But the hills, although abrupt, are not high, and consequently the highest rock of the series in this township is the *Sharpsville sandstone.*

Near the southern line a small stream puts into the right bank of French creek, cutting out a deep ravine along which the following section is exposed: (Fig. 60.)

Canal Freeder dam section.

Orangeville shale, (concealed,)	40′
Corry sandstone, Corry, (top 1270′ A. T.),	5′
Shales, soft sandy, bluish,	25′
Sandstone, flaggy,	20′
Cussewago sandstone, massive,	27′
Flags, fine-grained,	12′
Shale, blue, sandy, *fossiliferous,*	1′
Concealed,	5′
Shales, blue,	5′

Concealed,	5′
Sandstone, dark bluish, flaggy,	5′
Concealed,	12′
Sandstone interstratified with blue shale,	25′
Shales, blue,	5′
Concealed to level of French creek below the Canal Feeder dam,	53′

The shales at the top of the section are exposed in only one or two places; but these exposures and the smooth slopes, show that they are soft rocks belonging to the lower portion of the *Orangeville group.*

Orangeville group.—The *Corry sandstone* here shows rather massive layers of a buffish-white color, and rather fine-grained texture.

The *Cussewago sandstone* (named from these exposures) is a very coarse, dark, grayish-brown rock, the grains of which cohere loosely, and rapidly crumble apart on exposure. Just opposite our line of section where it has a very massive look, a quarry has been attempted and abandoned, as the stone proved useless for building, soon becoming a mere heap of loose sand.

In the fossiliferous blue shale I saw hundreds of specimens of *Productus Boydii*, and *Spirifera disjuncta*, besides a small *Orthoceras*. But *all the rocks of this section are fossiliferous* to a greater or less extent, *with one exception* the Cussewago sandstone, in which I could discover only some fragments of plants.

The 25′ sandstone interstratified with blue shale represents the *Venango First Sand*, and is the rock the bottom of which is nearly at railway grade at Meadville.

On Wolf run, near the northern line where the road crosses, near Mr. Bower's, the outcrop of the *Cussewago sandstone* is seen in the bed of the run; quite massive looking, but coarse and soft as usual; at 1220′ A. T.

About one mile below the village of Hayfield, or Little's Corners, a small stream plunges down over the steep hillside, and cutting out a deep ravine exposes the following section: (Fig. 61.)

Section below Hayfield.

Concealed,	20′

Sharpsville Upper Sandstone, flaggy,		25′
Meadville Lower Limestone, (1375′ A. T.),		2′
Sharpsville Lower Sandstone, flaggy,		10′
Limestone,		0′ 6″
Orangeville blue shales,	75′	
Sandstone, flaggy,	3′	88′
Blue shales (full of *Lingulae*),	10′	
Concealed,		13′
(*Corry SS.*) concealed and flaggy sandstone,		70′
Concealed to level of Cussewago creek,		100′

The *Meadville Lower Limestone* (rather flinty and with glassy fracture) is finely exposed and its peculiar round blocks are scattered along the ravine from its head to its mouth.

The *Sharpsville Sandstones*, upper and lower, are more massive here than usual; bluish-white, fine-grained, layers 1′ to 2′ thick, with very little interstratified shale.

The *Orangeville shale* as a mass is thicker here than usual along French creek. It is filled from top to bottom with *Lingulae* and *Discinae*; but I saw no other shells. The shales have a dark bluish color throughout, and are quite soft.

The *Corry Sandstone* is concealed, unless some exposed flags represent it.

At Hayfield village a small run descends from the highlands to Cussewago and along it the following section is seen: (Fig. 62.)

Hayfield section.

Orangeville shales,		20′
Corry sandstone, (1275′ A. T.),		5′
Shales,		40′
Cussewago Sandstone,	visible,	15′
Concealed to level of Cussewago,		130′

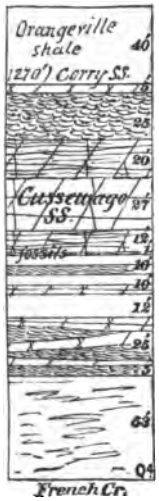
The *Corry Sandstone* has been *quarried* to a considerable extent at this locality, and the stones used for building the abutments of the bridge across Cussewago creek near Hayfield, and other purposes. It is a buffish-white rock and tolerably fine-grained. The stratum quarried is only about 3′ thick; top 1275′ A. T.

The *Cussewago Sandstone* is a very coarse, soft greenish-brown rock, and decomposing very readily. *Black Oxide*

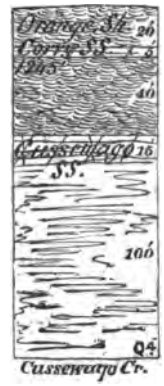
of Manganese (*Wad*) occurs in small quantities in the seams and cavities, and hence several trial entries made in search of *coal!* The rock lies about 400′ *lower* than any coal bed

61.

60.



62.



in Western Pennsylvania.

A bituminous shale, however, 2′ or 3′ thick, and looking a good deal like *cannel*, lies (as Mr. Little tells me) about 20′ below the base of the Cussewago Sandstone of this quarry. He showed me the horizon where it was once exposed, now covered up; and said that pieces placed on a fire burned with a feeble flame, leaving a quantity of ashes.

To geologists this thin and practically worthless *black slate* layer is of great interest, as feebly representing (probably) a large formation in Ohio: the *Cleveland Shale* of Dr. Newberry.

About one mile northwest from Hayfield on a small run, the following is seen where the road crosses the stream on the land of Mr. Bartholomew: (Fig. 63.)

Bartholomew's Section.

Corry Sandstone, (Top, 1280′ A. T.,)	10′
Shales,	3′
Cussewago Limestone,	2′
Shales,	30
Cussewago Sandstone, (Top, 1235′ A. T.,)	visible 10′

The *Corry sandstone* has been quarried here for buildings in the surrounding country; in layers 6″ to 18″ thick, tolerably fine-grained, grayish-white, with a tinge of yellow.

The *Cussewago limestone*, often found immediately below the *Corry sandstone* along Cussewago creek, is quite flinty, very much like the *Lower Meadville limestone* as exposed 2 miles further south, and 140′ (vertically) beneath it.

The *Cussewago sandstone* makes the bed of the stream; its top is quite hard for two feet; but below that the sand becomes coarse and coheres so loosely that one can remove it almost as easily as from a heap of silt-sand along any stream. The color is a greenish-brown but occasionally *black*.

Fragments of *woody plants* occur, carbonized and undeterminable, even generically

About one mile and a half south from Hayfield village, and half a mile below where section Fig. 6 was obtained, we get the following succession by descending a deep ravine toward Cussewago creek: (Fig. 64.)

Line's section.

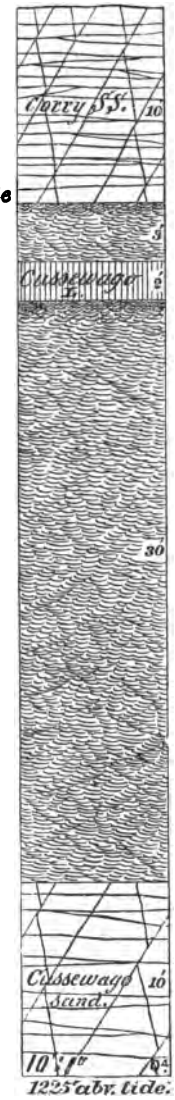
Meadville Lower Limestone, (1370′ A. T.)	2′
Sharpsville Lower sandstone,	10′
Orangeville shale,	115′
Corry sandstone,	15′
Cussewago Limestone,	1′ 6″
Flaggy sandstone and concealed,	30′
(*Cussewago sandstone*,) place,	—
Concealed to level of the Cussewago creek,	115′

The *M. L. limestone* outcrop follows the top of the hill across Mr. Line's farm. Some blocks of it built into the foundation of a barn turned black in a few years, became soft, and crumbled away, the rain water dripping from the eaves having leached out their lime and left the sand grains uncemented.

Nonconformability.—The effect of the unusual thickness here of the *Orangeville shale* (115′) is remarkable. *It reverses the dip of the underlying measures from southward to northward;* from *towards* to *away from* Meadville, distant 5 miles.* (See Fig. 48.)

	At Lines.	*At Meadville*
The *M. L. Limestone* lies, . . .	1370′	1322′
Interval (with *Orangeville* 115,)	140′	42′
Cussewago Limestone, ...	1230′	1280′
Interval, ...	30′	60′
Cussewago Sandstone, (top,) . .	1200′	1220′
Interval, ...	115′	—
Cussewago creek, ...	1085′	—
Railroad grade, at Meadville,	—	1080′
French creek at Meadville, .	—	1062′

63.



The *Corry Sandstone* consists of flaggy layers 6″ to 12″ thick, not quarried here.

The *Cussewago Limestone* is well exposed along the stream, and can with difficulty be distinguished from the *M. L. Limestone* 140′ above it, having the same glassy fracture and outward aspect.

The *Cussewago Sandstone* does not appear in its proper place 30′ beneath the limestone (See Fig. 63;) but Mr. Line tells me that he once dug into the hill at this horizon and found a loose coarse sandstone, which may represent it.

West from Mr. Kelley's where the road crosses the Hayfield run, the *Meadville Lower Limestone* is seen, (1385′ A. T.) 110′ above where the *Corry Sandstone* was once quarried along the same stream, further east, and 150′ above the top of the *Cussewago Sandstone.*

Ten feet below it is seen the thin limestone noted in the section, one mile below Hayfield just at the base of the *Sharpsville Lower Sandstone.*

[*That is, if the identification of the *Cussewago Limestone* and *Sandstone* at the two places be correct.—J. P. L.]

Barometric Elevations in Hayfield made with care and most of them checked closely:

Forks of road near Denny Bro.'s property, . .	(above tide,)	1140′
Cross roads at School-House, next north, . . .	"	1145′
Forks near E. Gant's, ...	"	1455′
" " Stephen Morse's, ...	"	1420′
" next north, ...	"	1410′
Cross road near D. H. Le Fevre's, ...	"	1415′
Forks near G. Moorhouse's, ...	"	1380′
Cross roads at Norrisville, ...	"	1370′
Forks near Wm. Watson's, ...	"	1350′
" " Edwin Kimple's, ...	"	1340′
Hayfield village, ...	"	1165′
Forks near Jas. McMillen's, ...	"	1180
" " A. J. Hollenbeck's, ...	"	1155′
" " Truman Randoll's, ...	"	1155′
" " Henry Lilley's, ...	"	1250′
" " T. Lenkhart's, ...	"	1220′
" " Geo. Kaler's, ...	"	1250′
" " Coon's Corners, ...	"	1275′
Forks next west, ...	"	1115′
Level of Cussewago opposite Hayfield, ...	"	1095′
" " at crossing near Southern line of township at A. Smith's, . .	"	1075′
Forks near Roderick Frazier's, ...	"	1270′
" " H. De Ross's, ...	"	1255′
Cross roads near W. L. Stockton's, ...	"	1370′
Forks near Edward Roger's, ...	"	1310′
" " A. H. Cole's, ...	"	1295′
Cross roads near Geo. Lewis's, ...	"	1260′
" " Jacob Brookhouser's, ...	"	1210′
Forks near Fred. Hickernell's, ...	"	1115′
" " Isaac W. Allee's, ...	"	1255′
" next north, ...	"	1300′
" near H. C. Hite's, ...	"	1320′
" " G. Bower's, ...	"	1220′
" " J. Hower's, ...	"	1275′
" next east, ...	"	1250′
" near Jno. Peter's, ...	"	1310′
Level of French creek near Peter Smith's, . .	"	1105′

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25. *Summer Hill, in Crawford county.*

This township lies on Conneaut creek north of Summit. Most of its rain fall reaches Lake Erie. Its eastern border drains east into the Cussewago. Its southeastern corner drains south into Conneaut lake.

The highest rock in the township is the *Sharpsville sandstone*, covering elevated land near the eastern border. The lowest rocks along Conneaut creek belong to the *Venango Oil Sand group.*

All along Conneaut creek, is a broad flat valley deeply filled with *Drift.*

On the land of J. R. Montgomery, two miles southeast from Conneautville, is a *quarry* in the *Corry sandstone*, from which a considerable amount of building stone has been taken. Top of quarry rock 1260′ A. T.; thickness, 8′; upper 5′ only quarried. The rock has its characteristic fine-grained and buffish-white color; and the layers vary from 6″ to 12″, occasionally thickening up to 3′.

Along the road where a cutting was made, just south from this, and 60′ higher, 20′ of blue *Orangeville shale* is seen, filled with *Lingulæ.*

About three miles south from Montgomery's, there is *another quarry* in the *Corry sandstone*, on the land of Mr. D. V. Miller. Top of rock 1200′ A. T.; thickness 10′ to 12′; aspect much the same as at Montgomery's, except that there is more interstratified shale. This quarry was largely worked for building the old canal locks.

Orangeville shale is exposed along the road, just east and above it; and identifies it.

Hammon's coal boring.—One half mile east from Miller's a boring was made for *coal* on the land of Mr. Hammon to a depth of 60′, and was abandoned, of course. It was absurd to expect coal 300′ (geologically) beneath the *Sharon conglomerate.*

Long's oil boring.—About one mile northwest from Dicksonburg an oil well was drilled on the land of Mrs. Long. One of the drillers gave me the following points *from memory*: (Fig. 65.)

Long's boring.

"Conductor hole, through gravel,"	40′
"Blue slate,"	40′
"Gray slate,"	20′
"White sand, gas,"	10′
"*Coal*,"	6′ to 8′

"Well drilled either to 618′ or to 680′; does not remember which; but is confident it was one of these numbers."

"At 110′ a dark substance was passed through which *they took to be* a thin bed of *coal*," probably bituminous shale.

Mouth of well 1145′ A. T.

Barometric elevations in Summer Hill.

Forks of road in Dicksonburg,	(above tide,	1000′
Level of Conneaut creek there,	"	990′
Forks near A. J. Lane's,	"	1060′
Cross-roads near D. V. Miller's,	"	1190′
" " Orin Wood's,	"	1290′
" " Jonathan Close's,	"	1265′
Forks near A. L. Stevens',	"	1320′
" J. Kelsey's,	"	1340′
Cross-roads near Wm. Dearborn's,	"	1300′
Forks near D. Doge's,	"	1280′
Cross-roads near A. Vaughn's,	"	1300′
Forks near H. H. Davenport's,	"	1175′
Cross-roads just west,	"	1145′
Cross-roads next west, near Conneaut creek,	"	1000′
Forks west from Dicksonburg one mile,	"	1175′
Cross-roads near M. Shaw's, at W. Line,	"	1155′
Level of creek at Conneautville,	"	930′
Cross-roads north from N. Houghtelling's,	"	1215′
Forks near M. T. Carr's,	"	1255′
Cross-roads near P. Ford's,	"	1280′
" " J. R. Montgomery's,	"	1280′
" " Jno. Steel's,	"	1275′
" north from Jno. Cooper's,	"	1280′
Forks next east,	"	1280′

26. *Conneaut, in Crawford County.*

This township lies along the Ohio State line, around the head-waters of Peyton run, or north branch of Shenango river, draining south. The northern township line runs along the great divide; and brooks in the northeast corner flow east into Conneaut creek and Lake Erie.

A large portion of the township has a nearly uniform level of about 1100′ A. T. A good deal of low and swampy land is in the township. There are no deep valleys, and the whole surface is covered with a thick coating of *Drift*, so that very few rock exposures can be found.

The highest rock is the *Corry Sandstone*, quarried to a small extent along its southern line.

Just south from Summit Station the *Cussewago Sandstone* is seen along the road which passes north and south parallel to the E. and P. Railroad. It possesses the same loose incoherent texture here as so often elsewhere; at first sight I mistook its outcrop for a heap of *Drift sand;* for marks of the spade were left where it had been shoveled for making lime mortar. On closer examination shales and harder layers of sandstone, regularly stratified, were found on top of it. The sand has a greenish hue, and contains a considerable quantity of smoothly worn pebbles of quartz, mostly flat in shape.

Only 6′ to 8′ of the top of this curious deposit could be seen; its top was accurately determined by leveling from Summit Station on the E. and P. Railroad, near by, to be 1160′ A. T.

About one and a half miles south from Summit Station the *Corry Sandstone* has been *quarried* to a small extent on the land of Mr. Daniel Spaulding; in irregular buff-colored flags 3″ to 6″ thick; 1180′ A. T.

About one mile west from this and on the opposite side of North Shenango creek the top of the *Cussewago Sandstone* is seen exposed along the roadside, with the same character as near Summit Station, except that near its top are seen many pebbles of shale; exposure, 10′; top, 1120′.

About one fourth of a mile north from this the same deposit is seen along a ravine which crosses the road.

Barometer elevations in Conneaut.

Cross roads east from Summit Station, ...	(above tide,)	1155′
Forks next east, ...	"	1175′
Cross roads near D. E. Fanner's, ...	"	1180′
" " J. Wyatt's, ...	"	1160′
" " H. D. Lowing's, ...	"	1160′
" at Conneaut Center, ...	"	1155′
" near Wm. Graham's, ...	"	1060′
" at Steamburg P. O., ...	"	1090′
Forks near Alex. Fenner's, ...	"	1100′
Cross roads near A. Stevens' at eastern line of township, ...	"	1155′

27. *Beaver, in Crawford county.*

This township occupies the northwest corner of the county, and five parallel streams flow through it northward into the west branch of Conneaut creek. They rise on the southern slope of the great divide and flow north about one mile apart, in remarkably straight courses, and with a rapid fall.

The rocks exposed belong entirely to the *Venango Oil Sand group*, and near the northern line of the township the *Third sand horizon* lies within a few feet of the surface.

Oil borings, to the number of twelve or fifteen have been drilled in this township, and the Survey is indebted to Benjamin Stimpson of Conneautville for the following interesting account of them, sent to Mr. Carll, and communicated by him to me:

"Sometime between the years 1795 and 1800 a well was drilled for salt in the southwest corner of Beaver township by Col. Shryock. As near as I can ascertain, the well was 300′ deep. It was tubed with wooden tubing 2½ inches in diameter, with the bore hole 1½ inches. The joints were 6′ long, connected by wooden screws and banded with copper. Salt was manufactured for a time, but on going deeper oil was found in such a quantity as to cause the abandonment of the salt business.

"The show of oil in the old salt well induced me to go there and drill the first well that I have put down in this township. Before I commenced drilling in Beaver, eight wells had been sunk, ranging in depth all the way from 80′ to 1624′. I can give you no accurate report of these wells.

"I have found some oil in every well that I have drilled, and it has in all cases been of a dark green color, and very fine lubricating oil, ranging from 19 to 23 gravity.

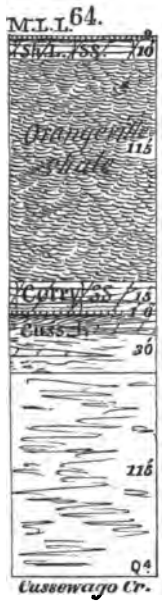
"I enclose to you with this, records of the different wells drilled by me with such information, so far as I can give it, which seemed to be required by your letter.

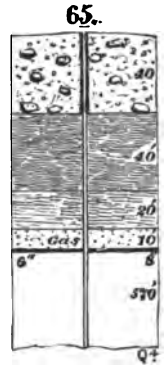
"You will observe that these wells have all been drilled north from the Summit, and while I have found some oil in

each well I am of opinion that it will not be found in paying quantities on the northern slope.

"When we go south of the Summit in Conneaut township for some miles, we find the bed rock from 3′ to 48′ in depth below the surface.

"In all my drillings on the north slope, I have never met with any *black shale or black slate.*"





Record of Well No. 1. (*Fig. 66.*)

"In April, 1874, I drilled a well at a place called Reed's Corners, seven miles west from Conneautville, and at an elevation of about 200′ above that place."*

The well was sunk to a depth of 500′. Struck bed-rock at 29′. Drilled through rock for 145′, which was principally slate, with an occasional sandy shale. At that depth struck a *Berea formation.*† In that I struck a heavy gas vein and some slight show of oil after drilling 18′. This *Berea rock* was 145′ in thickness. At 196′ from the surface I struck another very heavy gas vein. At 285′ I struck a formation of sand and white pebble 20″ (inches) thick.‡

"After this I had soapstone, slate, and occasionally a shell to the depth of 380′. Then I struck a *Berea formation* 20′ thick, and the rest of the drilling was through soft slate rock.

"Cased the well to depth of 128′; shut off the water and pumped it for four days with no result, when it was abandoned."

Record of Well No. 2.§ (*Fig. 67.*)

"In the spring of 1875 I drilled a well at Beaver Center, about 7 miles N. W. from Conneautville, and 3 miles north from the Summit. Struck bed-rock 3′ from surface. Drilled 60′ through slate, soapstone, and an occasional shell. At

(*This would make it 1140′ above tide; but I determined the elevation of Reed's Corners by barometer to be 1110.—I. C. W.)

† With reference to a term frequently used by Mr. Stimpson in these records there may be some misapprehension, viz: the phrase "*Berea formation.*" I did not understand what was meant by it myself at first, but Mr. Schofield, of Conneautville, who is intimately acquainted with Mr. Stimpson, and who in drilling wells has used the same phraseology, informed me that by "*Berea formation*" Mr. Stimpson intended to describe *a tolerably fine-grained, bluish-white sandrock*, or succession of them, which he fancied resembled the famous stone at Berea, Ohio, and which he believed to be identical with it. This, of course, it cannot be, since in all the wells except the first his "*Berea formation*" is identical with the *Venango Third Oil Sand horizon*, lying (geologically) more than 300′ below the horizon of the true "*Berea formation*" of Berea, Ohio.

‡ *Third Oil Sand.*—I. C. W.

§ Commenced at an elevation of 1000′ above tide, as I determined by Barometer.—I. C. W.

that depth I struck the *Berea formation*, which was 45′ thick. Three feet below its top I struck gas and considerable oil. At 72′ from the surface struck another gas vein. This well I drilled to the depth of 200′, and the rest of it was through soft slate.

"I cased down to a depth of 50′, where I shut off the water and pumped for six days, during which time I obtained four to six gallons of oil of the same quality as that in well No. 1."

Record of Well No. 3. (*Fig. 68.*)

"This I drilled in the spring of 1876, on the Bentley farm, about 9 miles northwest from Conneautville, and 5½ miles north from the Summit.

"Depth of well, 145′.

"Struck bed-rock at 17′, and the *Berea formation* at 36′ from the surface. The Berea rock was 26′ thick. At 52′ from surface struck a gas vein with slight show of oil. The balance of the depth drilled showed very soft slate.

"Cased to depth of 26 feet to shut off water, and then pumped it five days with no show of oil."

Record of Well No. 4, (*Fig. 69.*)

"In the Spring of 1877 I drilled a well for M. W. Clay & Co. on what is known as the Cornell farm, 9½ miles northwest from Conneautville, and 6 miles north from the Summit.

The well was 122′ deep. Struck bed-rock 4′ below surface. At 26′ struck the Berea formation; and at 33′ from surface I struck a vein of oil and gas. The *Berea formation* was 20′ thick. At 116′ struck a fine gray sand 3′ thick, with a small vein of oil just beneath. The rest of the drilling was through soft slate.

"I cased this well to 28′ and tubed it down to 120′. Pumped it three months. My impression is that it produced from four to six gallons of oil per day.

After pumping three weeks we put on a double acting gas pump to see if we could not increase the production, but it had no appreciable effect."

On discussing Mr. Stimpson's data, it appears

1. That the *Venango Third Sand* is represented by the 3′ pebble rock, 285′ down Well No. 1, = 825′ A. T.

Proof:—Base of *Corry SS.* (as calculated by rate of dip, from nearest outcrop to the south, 5 miles) about 1275′ A. T.—Difference, 1275′—825′=450′.—Compare same difference on Oil creek.

2. That the *V. Third S.* is represented by the "Berea formation" (base) 108′ down Well No. 2=892′ A. T.

Proof 1:—Base of *V. Third S.* in bluff of Conneaut creek, at Spring P. O., 5 miles due east, 885′ A. T.

Proof 2:—Rise of base of *V. T. S.* from Well 1 to Well 2, distance 3 miles, direction due north, 892′—822′=70′; rate of rise 23′ per mile.

3. That the *V. T. S.* is represented in Wells Nos. 3 and 4, by Mr. Stimpson's "Berea formation"; for although the mouths of those wells were not leveled, yet the topographical tracing is easy.

Near the southeast corner of this township, a *quarry* has been worked to some extent on the land of Mr. Petit, in a bluish-gray stratum, containing many *Fucoids* between the layers; it comes at the horizon of the *Venango First Oil sand*, 1105′ A. T.

Barometric elevations in Beaver.

Cross roads in Beaver Center,	(above tide,)	1010′
" near Alex. Hamilton's	"	1040′
" " Jas. McClure's,	"	1110′
" " E. J. Carey's,	"	1090′
" " M. Irish's,	"	1140′
" " S. Sherwood's,	"	1125′
" " Nash and Coxan's,	"	1055′
Forks of roads near C. Larned's,	"	1040′
Cross roads near Mrs. Greenlee's,	"	1010′
" east at township line,	"	1020′

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28. *Spring, in Crawford county.*

This township lies between Conneaut creek and Cussewago creek along the Erie county line. The western, central, and northern portions drain through Conneaut creek into Lake

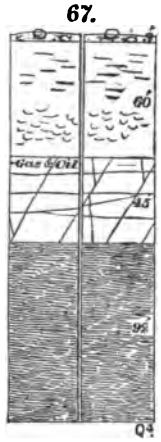
Erie; the eastern portion drains south through the Cussewago and French creek into the Allegheny river.

The middle highland lying north and south through the center of the township is about 1250′ A. T.

The *Corry sandstone* is the highest rock and is caught in

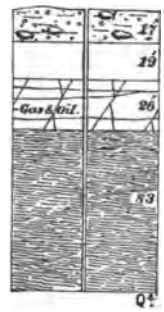
Beaver Center Well No. 2.

67.



Beaver Center Well No 3.

68.



Beaver Center Well No. 4.

69.

knobs along the southern line. The lowest rock cut into by Conneaut creek where it leaves the county is about 100′ below the *Venango Third Sand.*

This latter stratum is seen outcropping on the banks of the Conneaut creek at Spring P. O., in the following section: (Fig. 70.)

Venango Third Sandstone, ... 20′
Blue shales, with iron nodules to level of Conneaut creek, . . 15′

The sandstone is flaggy above and rather massive below; of a peculiar bluish-gray color, and tolerably fine-grained. Base of the mass, 885′ A. T.

The shale is very blue, soft, and fine-grained, and holds some nodules of iron, multitudes of *Fucoids*, but no other fossil forms.

On the opposite side of the creek, just east from Spring village, the outcrop of a tolerably massive sandstone is seen in a ravine which runs parallel with the road, at 1055 A. T.

At Spring village, Conneaut creek flows over rock; but

as it runs along the western side of the valley, there may be a buried valley east of it, near the village.

Oil well.—About two miles south of Spring village, and one mile below Conneautville, on the land of Mr. Powers, one rod east from Conneaut creek, 5 feet above its level, and near the center line of the valley, a well was drilled by Mr. Schofield, of Conneautville, who gave me the following record (Fig. 71):

Schofield's Boring.

"Drive-pipe,"	112′	to 112′
"Soapstone (here large gas vein"),	4½′	to 116½′
"Soapstone,"	25½′	to 142′
"Quicksand,"	45′	to 187′
"Slate,"	3′	to 190′
"Berea formation,"	?	to ?
? to bottom of well at	?	to 750′

At 322′ a good show of green oil was got. At 510′ a gas vein and very strong salt water was struck. At 750′ a very large gas vein was struck—"enough at first to light Conneautville."

Quicksand.—A very singular thing in this well was the striking of a bed of "quicksand" after the drill had penetrated to a depth of 142′, and had apparently passed through 30′ of bed rock. Drive-pipe was first put down to a depth of 112′, where the drill appeared to strike bed-rock, but when it had passed through "the soapstone" the tools dropped several feet, and the "quicksand" boiled up to the top of the hole "like mush," as Mr. Schofield expressed it, so that the drive-pipe had to be continued down through the "quicksand" to genuine bed-rock, "slate," before the drilling could be proceeded with.

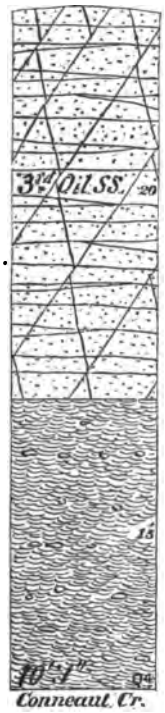
The presence of a regular bedded rock at the horizon of Nos. 2 and 3 may be accounted for by the sliding down of a large mass of rock from the steep cliffs which probably bounded the walls of the ancient valley that now lies buried so deeply under 187 feet of detritus, so that it was a mere bowlder resting on the quicksand, or it may have been a projecting ledge of slate from an over-hanging cliff of the rocky wall which bounded the ancient narrow valley.

The well commences at 925′ A. T. and the bottom of the old filled up valley was here 925′—187′=738′ A. T.

Mr. Schofield reports that at the depth of 110′ a small bed of [*Drift*] pebbles was encountered mostly water-worn, and among them was a crystal of quartz.

Burn's well.—About one mile north from this, on the Burn's farm, another well was drilled near one side of the

70.



71.

valley and soon struck rock. Nothing could be learned about it except an abundant flow of salt water.

Dunn's well.—One and a half miles from the eastern line of the township, an oil well was bored on the land of Mr. N. W. Dunn. No oil was obtained, but at a depth of 400′, a large gas vein was struck which blew the tools out of the well and made a very large blaze when burning. No pebbly

rocks of any importance were encountered in the drilling. Top, 1215′ A. T.—Depth, 512′.

Barometric elevations in Spring.

Cross roads in Spring village,	(above tide,)	895′
Level of Conneaut creek, just opposite,	"	870′
Forks of road near N. Spencer's,	"	920′
Cross roads at township line west from Spring station,	"	1020′
" at Clark Eighmy's,	"	1190′
" at S. W. Sheldon's,	"	1150′
Forks near G. W. Prussia's,	"	1200′
Cross roads near Mrs. Water's,	"	1165′
" " Dennis Hardsell's,	"	1260′
" " J. Sperry's,	"	1200′
Fork of road at cheese factory, near southeast corner of township,	"	1185′
Forks near M. Roger's,	"	1235′
" A. S. Smith's,	"	1330′

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29. *Cussewago, in Crawford county.*

This township on the Erie county line lies between the Cussewago creek and the brooks that flow east into French creek.

Cussewago creek rises near the county line and flows with very sluggish movement south through its western quarter.

The southern portion of the middle highland reaches 1500′ A. T. capped by the *Sharpsville sandstone.*

In a deep gulch near Hotchkiss's school-house, the top of the blue *Orangeville shale* is 1445′ A. T., and above it lies the bluish gray *Sharpsville sandstone.*

The shale shows itself at several points along this ridge in the roads, and occasionally also the sandstone above it.

Along the Cussewago valley every thing is deeply buried under *northern Drift*, and no rocks are visible.

Barometric elevations in Cussewago.

Cross roads in Mosiertown,	(above tide,)	1235′
Forks at John Miller's,	"	1215′
" near Alfred Eaton's,	"	1235′
" " J. S. Morris's,	"	1245′
" " Jason Davis's,	"	1290′

" " A. B. Heard's,	(above tide),	1285′
Cross roads near Geo. Joslin's,	"	1275′
Forks next east,	"	1340′
Cross roads near H. D. Freeman's,	"	1415′
" near Henry Hotchkiss's,	"	1455′
Forks near Geo. W. Muckinhaupt's	"	1508′
Cross roads near Jas. Hamilton's,	"	1435′
" " H. J. Lake's,	"	1480′
" next north,	"	1390′
Forks near D. Loney's,	"	1380′
" Thos. McLaughlin's,	"	1250′
Crossingville (at cross roads),	"	1125′
Level of Cussewago, here,	"	1115′
Forks near A. M. Sherred's,	"	1120′

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30. *Venango, in Crawford county.*

This small township on the Erie county line, stretches north and south along the western bank of French and Conneautee creeks; and its surface, which at its western border is quite elevated, (more than 1400′ A. T.) slopes rapidly down east towards French creek, the bed of which is about 1120′ A. T.

Along the western border the outcrop of the *Orangeville shale* is often seen in the roads, and at some points the hills are high enough to catch the *Sharpsville Sandstone*, or its lower portion.

About one mile west from Venango Village, in a deep gulch just south from the forks of the road at Mr. J. Morris's, the following section is seen: (Fig. 72.)

72.

Morris Section.

Orangeville Shale,	visible,	20′
Corry Sandstone,		15′
Concealed,		5′
Cussewago Limestone, (1345′ A. T.,)		2′
Concealed to level of French creek at Venango,		230′

The fine blue *Orangeville Shale* contains *Lingulæ* and

Discinæ; where exposed in the road many of the layers are coated with a film of iron rust.

The *Corry Sandstone* has been *quarried*, to some extent, just below the road, the top quite massive and furnishing some excellent building material, of characteristic yellowish-white tint. The lower portion, rather shaly, has not been quarried.

The *Cussewago Limestone* is here an unusually massive layer of hard rock, huge blocks of which 6′ to 8′ square, and 2′ thick, lie along the little stream, as they have been torn from its bed. Possessing more lime than usual in its composition, it has been burned with some success by Mr. Norris, into good white lime. The rock is very compact and breaks with a sharp angular fracture, and the characteristic glistening surface so often alluded to in this report.

The *Venango Third Sand horizon* cannot be much more than 200′ below water-level at Venango village, as will be seen by the following thickness of rock which intervenes between the creek at this locality and the horizon of the *Sharon Conglomerate.*

Sharon Conglomerate, down to *Cussewago Limestone*, . . .	335′
Cussewago Limestone to level of French creek, ...	230′
Add	200′
	765′
Adopted normal depth of the *Venango Third O. S.* beneath the *Sharon* Conglomerate, ...	750′.

On the right bank of Stewart's run, near Mr. Skelton's, the outcrop of a sandstone is seen, and some massive blocks are scattered over the surface, of a grayish-brown color and tolerably coarse texture (but no pebbles), at 1245′ A. T. This is the right height for the *Venango First Sand.*

Barometric elevations in Venango.

Level of French creek at Venango village, . .	(above tide,)	1115′
Forks of road one mile west at A. Miller's, . .	"	1265′
" near J. Norris', ...	"	1380′
" " Levi Colter's, ...	"	1190′
Cross-roads near J. R. Holman's, ...	"	1190′
Forks near Andrew Sherred's, ...	"	1220′
Cross-roads north from Andrew Hagelbarger's,	"	1240′
Forks next north, ...	"	1230′

Level of Stewart's run, just north of last, . .	(above tide),	1170′
Forks of road near W. Blystone's, ...	"	1200′
Cross-roads near J. W. Rubner's, ...	"	1285′
" " James Torry's, ...	"	1200′
" next east, ...	"	1180′

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31. *Cambridge, in Crawford county.*

This lies directly east from Venango, having French and Conneaut creeks for its western boundary, Erie county on the north, and Rockdale township on the east. It has about the same area as Venango, and almost the same shape. French creek which flows across its center from east to west, and then south along its western borders, carries off all its drainage.

The surface north of French creek is almost a level plain, from 1150′ to 1200′ A. T.

Along the southern line the surface rises to the *Orangeville shale*, and most of the *Sharpsville sandstone*; 1450′ to 1500′ A. T.

At Venango station on the A.G.W.R.R. the following succession is seen descending the steep bluff: (Fig. 73.)

Venango Station section.

1. Flaggy sandstone to R. R. level (1163′ A. T.), ... 10′
2. Shales *reddish*, ... 10′
3. Flaggy sandstone, ... 8′
4. Shales, *red, chocolate, &c.*, ... 12′
5. Shales, blue, to level of French creek, ... 23′

No. 1 is seen in a cutting just above the station, and some of its layers are quite massive; it may represent one of the *Venango sands;* but since (by calculation) the *Venango Third sand* should here lie 200′ beneath the creek, these flags are too high for the *Second* and too low for the *First.*

No. 5 is a very fine blue shale interstratified at every few feet with thin sandy layers, and occasionally some *chocolate shale.*

Barometric elevations in Cambridge.

Level of French creek at Cambridge, ...	(above tide,)	1130′
Forks near C. A. Mansfield's, south of Cambridge, ...	"	1340′

Cross roads near Mrs. Harmon's, ...	(above tide),	1350′
Forks near J. K. Hawthorn's, ...	"	1430′
" Daniel Root's, ...	"	1425′
Cross roads near M. Kelly's, ...	"	1450′
Forks at brickyard, north from Cambridge, . .	"	1140′
Cross roads near H. Goodwin's, ...	"	1190′
Level of Conneaut creek at Drake's Mills, . .	"	1140′

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32. *Rockdale, in Crawford county.*

This township surrounds the junction of Muddy creek with French creek. Muddy creek comes in from the southeast with a scarcely perceptible flow.

The eastern line of the township follows a divide between the waters of French creek and Oil creek, some of the hills attaining to 1650′ A. T.

Smith's quarry.—About one mile west from Brown's Hill P. O., a sandstone stratum has been quarried to some extent on the land of Mr. Smith; a buffish-white rock, rather hard and tolerably fine-grained; the base somewhat coarse with some pebbles. The rock resembles and is here at the proper altitude for the *Corry sandstone*, viz: (top) 1520′ A. T.

A yellowish white (*Sharpsville*?) sandstone appears on a hill, a mile south of Smith's quarry, and 100′ higher level. The bottom layers of the mass are exposed (1650′ A. T.)

In the southeast corner of the township, near J. Fausburg's, the outcrop of a buffish-white sandstone is seen (at 1510′ A. T.), which very much resembles the Smith's quarry rock, one mile north, which I supposed to be the *Corry sandstone.*

Descending the hill westward toward Muddy creek, we come to the outcrop of a dark flaggy sandstone, 170′ below the *Corry sandstone*, apparently about 10′ thick, and quarried here and there on the land of Mr. Parker. It lies at about the right horizon below the *Corry sandstone* for the *Venango First sand* 200′ above Muddy creek.

About three miles west from this, near Bunce's cross-roads, flaggy sandstone was quarried a little, in a ravine on the land of Mr. Bunce; layers, 1′ to 2′; rock, dark-gray,

rather fine-grained; whole mass only 10′; elevation, 1225′ A. T.

Just east from B. Wheeler's, at the western line of the township, an outcrop very much resembling the *Cussewago sandstone* occurs at about the right horizon here: 1425′.

About three fourths of a mile west from Miller's station, on the A. & G. W. R. R., a bed of blue flagstone has been quarried by Mr. Wilcox; the surface of the flags covered with *Fucoids;* a great many shells seen; among them *Spirifera disjuncta;* elevation, 1200′ A. T.

Passing north from this, up the hill, we come to the base of a tolerably massive sandstone—making a steep bluff, and just beneath it a *Spirifer band*, filled with shells at 1315′ A. T.

Still further north, at Saeger's cross-roads, the ground is covered with many bowlders of a yellowish-white sandstone (probably *Corry*), at 1475′ A. T.

Barometric elevations in Rockdale.

Level of French creek, opposite Miller's Station,	(above tide),	1135′
Forks west from Miller's at D. I. Wilcox's,	"	1165′
Cross-roads near John Saeger's,	"	1475′
Forks near B. R. Bumb's,	"	1325′
" " Amos Anderson's,	"	1345′
Cross-roads west from Gage's School House,	"	1260′
Forks east from Miller's Station, near G. Wilson's,	"	1170′
Next southeast,	"	1160′
Forks near Woodside's mill,	"	1170′
" " G. Field's,	"	1200′
" " G. D. Ferris',	"	1180′
" next southeast,	"	1195′
" near U. Kelley's,	"	1175′
Level of Muddy creek, near Shingle Mill,	"	1140′
Forks near John Willis',	"	1150′
Cross-roads near C. F. Bunce's,	"	1225′
Forks near G. May's,	"	1220′
Crossing of Mohawk run due west,	"	1220′
Cross-roads near Cheese Factory next west,	"	1250′
" " M. Kelley's,	"	1450′
Forks of road at Brown's Hill P. O.,	"	1460′
Summit, ½ mile east,	"	1570′
Cross-roads at township line, next east,	"	1485′
" " " next south,	"	1555′

Summit, ½ mile west from last,	(above tide),	1650′
Cross-roads near J. Fausburg's,	"	1490′
Forks near N. Alexander's,	"	1185′
" next west at School-House,	"	1175′

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33. *Bloomfield, in Crawford county.*

This township surrounds Oil Creek lake. It is drained by Oil creek west branch southeastward.

Oil Creek lake, the highest of the Crawford county lakes, (1389′ A. T.) is surrounded by hummocks of *Drift*.

The western line hills reach a height of 1600′ A. T., and those along the northern or county line, 1700′ A. T.

The highest strata in these summits belong to the *Orangeville shale*, but in two or three places patches of the *Sharpsville sandstone* remain.

In the vicinity of Oil Creek lake, several oil wells have been drilled, and the following record was given me by Mr. T. L. Dobbins, of a well drilled by him in 1878, at Oil Creek station (Lakeville), 9′ above R. R. grade (1412′):

Dobbins' oil well.

Mouth of well,	0′		1420′ A. T.
"Conductor hole,"	14′	to 14′	1406′
"Very hard sandstone,"	30′	to 44′	1376′
"Slate (red rock at 209′ from top),"	331′	to 375′	1045′
"Sand, good, pebbly, some oil," (*Third oil sand.*—I. C. W.),	9′	to 384′	
"Slate,"	146′	to 530′	
"Sand shells, fragments in this interval, one containing pebbles at 594′,"	120′	to 650′	
"Soft slate,"	262′	to 912′	
"Sand shells, very hard,"	20′	to 932′	
"Soft slate, to bottom of hole,"	68′	to 1000′	

Rightly to understand this record, it is necessary to connect it with an outcrop of the *Corry sandstone* in the ravine next west of the hole; the *base* of the rock lying 85′ above R. R. grade, or 1496′ A. T.

Corry SS. (*base*) 1496′—top of pebbly sand in well, 1045′ =451′=about the depth of *Third Oil sand* beneath *Third mountain sand* in Venango county.

Mr. Carll has himself identified the *Corry sandstone* in

the ravine at Lakeville with the *Third mountain sand* of Lower Oil creek.*

The two following records of wells drilled near Oil Creek lake by Mr. Dobbins, are re-published from Mr. Carll's report I.I., pp. 273–4.

Oil Cr. Lake Lumber and Mining Co.'s Well, No. 1. Near the saw-mill.

Well mouth, *above ocean, in feet*, about 1400′ A. T.,		0′
Drive-pipe,	13′ to	13′
Slate or shale,	100′ to	113′
Rock, hard blue, water vein,	1′ to	114′
Sandstone crust,	1′ to	115′
Slate and shale,	48′ to	163′
Slate, blue,	100′ to	263′
Rock, hard,	52′ to	315′
Slate and gray sand,	50′ to	365′
SANDSTONE, white (THIRD). oil show,	2′ to	367′
Soapstone and soft blue slate, with hard streak,	63′ to	430′
Slate, gray, with white sand-shells,	37′ to	467′
Slate, blue,	33′ to	500′
Slate, blue, with flint and white sand,	36′ to	536′
Shale and gritty sand shells,	14 to	550′
Slate,	55′ to	605′
Slate, with threads of gray sandstone,	370′ to	975′

Wet hole. Never tubed nor pumped. Show of oil at 180′, 367′, and 506′. Some gas at 542′.

Well No. 2. (Near Oil Creek Lake and R. R. Water-tank.)

Well mouth, *above ocean, in feet*, about 1405′ A. T.,		0′
Drive-pipe, through coarse gravel and blue clay,	30′ to	30′
Soapstone, light-blue, and slate, with hard streaks,	103′ to	133
Blue slate and sand shells,	15′ to	148′
Slate, blue, with hard streaks of sand,	80′ to	228′
Slate, blue,	50′ to	278′
Slate, red,	15′ to	293′
Slate, blue,	80′ to	373′
SANDSTONE, white (THIRD), *show of oil*,	2′ to	375′
Slate, blue,	6′ to	381′

* A comparison of this record with those obtained at Sharon, Mercer county, and Beaver Falls, Beaver county, will show that interval No. 3 of this well, corresponds to the 305′ shale at Sharon, and to the 366′ of soft rock between base of 124′ sandstone and 30′ rock at Beaver Falls. Hence the 75′ rock at Sharon, and the 124′ rock at Beaver Falls must be the equivalent of the *Corry sandstone* (3d mountain), *and the rest of the interval down to base of No. 2 in the Lakeville well*, including the Cussewago sandstone, and probably some other measures below it.

S.S. and pebble, very hard, estimated,	5′ to 386′
Slate, soft, with hard streaks,	114′ to 500′
Slate, blue and rather hard,	88′ to 588′
Rock, very hard,	2′ to 590′

Wet hole. Never pumped.

At about 100′ oil-soot, and show of oil (same as other well at same depth). At 125′ hard streaks and better show of oil.

One foot crevice and water at 142′. Fair show of oil at 383′. Gas at 542′.

One Riceville well was drilled on the east bank of Oil creek, in the triangular space at the junction of Negus run with the creek; operator, Mr. Kerr, of Titusville; well mouth, 1330′ A. T.; depth, 1000′; 15′ of drive-pipe; some oil at 60′; none below that.

This oil horizon comes 200′ below the top of an outcrop of the *Corry Sandstone*, seen half a mile west of the drill-hole. A bed of greenish-blue shale is visible in the bottom of the creek at Riceville.

Another Riceville oil well was put down on the west bank of the creek, and some oil obtained at 60′; but none below that.

About one and a half miles east from the northern end of Oil Creek lake, and a short distance west from the cross-roads at J. B. Paige's, is seen a 15′ exposure of *Corry Sandstone*, the lower portion quite coarse, and containing small pebbles. Top, 1540′ A. T.

Barometric elevations in Bloomfield.

Level of Oil creek at Riceville,	(above tide),	1325′
Cross-roads east from Riceville,	"	1445′
Forks of road near Mrs. S. Welden's,	"	1635′
" next west,	"	1605′
Cross-roads next west,	"	1535′
" near J. B. Paige's,	"	1575′
Forks near Southeast end of Oil Creek Lake,	"	1405′
Cross-roads near Mrs. Nicholson's,	"	1435′
" " I. Miller's store,	"	1610′
Crossing of Mosey run, next west,	"	1450′
Cross-roads near Thos. Lee's,	"	1540′
" " Jacob King's,	"	1670′
" at township line west,	"	1560′

34. *Sparta, in Crawford county.*

This township occupies the northeast corner of the county, against the Warren county line, and encloses Mill Pond and the numerous heads of Oil creek east branch. One branch of Spring creek heads in the eastern part of the township and flows east.

The highest land in Crawford county is found in this township; many summits rising to 1800′ A. T. and upwards, and holding outliers of the *Shenango sandstone*; as, for example, at Mr. Bates', on the State road, one and a half miles east from Spartansburg, where a well (1760′ A. T.) was sunk several feet in this coarse brownish iron stained rock, containing here some small flat pebbles.

About one mile further east, along the State road, the *Shenango sandstone* causes the bluff slope around the hills, and its outcrop is exposed in the road, and in a neighboring field; quite coarse and massive; base, 1755′ A. T.

Near the Warren county line, a *very large spring* issues from beneath a yellowish-white sandstone at (1600′ A. T.) The *Corry* horizon of springs has already been noted.

Crossman's well.—Just on the line where the Pittsburgh, Titusville and Buffalo R. R. passes out of the county, a well was drilled for oil, on the land of Mr. Crossman, in the summer of 1878, to a depth of 1200′; mouth 1575′ A. T.; drive pipe 150′;* vein of heavy green oil and much gas at 400′.

The *Shenango sandstone* is found in the hills west from this (base) at 1850′ A. T. so that this oil horizon probably represents the *Venango Third sand.*†

Mr. Crossman tells me that the oil obtained at 400′ was as heavy as the Mecca oil of Ohio; but that it only comes up in small quantities, and no oil was obtained below 400′.

* The great depth of *Drift* indicates an important pre-glacial valley cutting through the high divide, towards Corry, along the line of the Pittsburgh, Titusville and Buffalo R. R., the summit grade of which is only 1646′ A. T., while the hills on each side rise more than 200′ above the road. The well is within half a mile of the summit, and on the line of the thorough cut.

† 1850′—1575′+400′=675′; add 75′=750′ the proper height of the *Sharon Conglomerate* above *Third sand.*

Just east from the cross roads at Mr. Webb's near the western line of this township the outcrop of the *Corry sandstone* is seen along a small stream; is 10′ thick; yellowish-white; quite massive and many large blocks scattered around. A line of springs issues from its base at 1560′ A. T. Top of the rock 1570′ A. T.

About two miles south from this, and just west from the cross-roads at D. E. Winton's, the outcrop of the *Corry Sandstone* is seen at 1540′ A. T.

Barometric elevations in Sparta.

Forks near A. Bates's on State road, ...	(above tide,)	1670′
Summit east from that at Eastman's, (Carll,) .	"	1798′
Crossing of stream at eastern line of county on State road, ...	"	1665′
Cross roads at Webb's near western line of town'p, ...	"	1580′
Level of run near C. Messenger's, ...	"	1415′
Forks of road near J. Fralich's, ...	"	1390′
Level of creek there, ...	"	1390′
Cross roads near D. B. Winton's, ...	"	1375′
Level of creek east, ...	"	1300′
Forks near E. Day's, ...	"	1565′

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35. *Concord, in Erie County.*

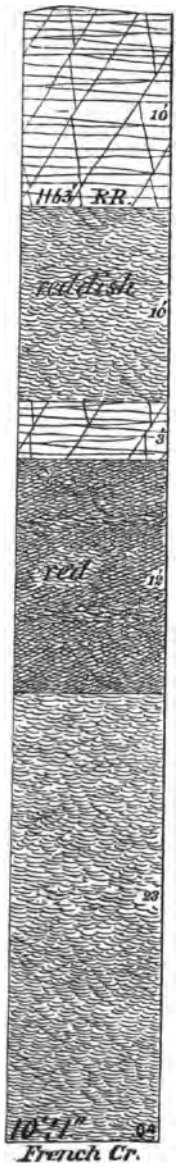
This township occupies the southeast corner of Erie, and its drainage all finds its way eventually into the Allegheny river, by three routes.

From the very high east and west dividing ridge the rainfall flows into the south branch of French creek, and so westward. The southern slope drains directly into Oil creek through Crawford county. The eastern slope drains into the Brokenstraw, and reaches the Allegheny river at Irvineton.

There is scarcely any perceptible divide between the waters of the south branch of French creek at the western end of Corry and those of the Brokenstraw at the eastern limit of the borough; and the whole topography looks as though the Brokenstraw may once have emptied through this low divide into the French creek valley.

The most elevated land in Erie county is on the high ridge

73.



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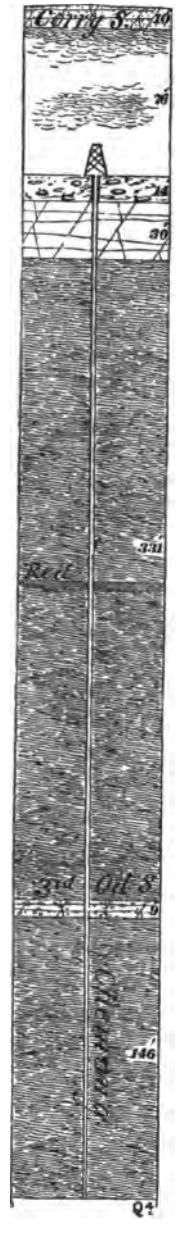

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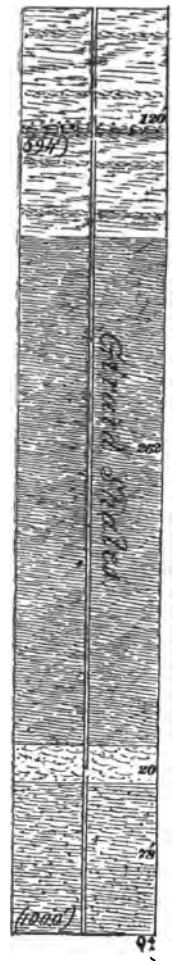


south of Corry; much of it 1800′ A. T., and many knobs reaching 1860′ A. T.

East of the center of the township there is a low passage-way through this ridge, 200′ below its general level, through which the Pittsburgh, Titusville and Buffalo R. R. passes; the railroad summit grade being 1646′ A. T.

This buried valley has been described in Part II, p. 36.

Drift fills the valley of South French creek one or two miles broad, and in the neighborhood of Corry are wide level reaches of Drift deposits.

Corry Sandstone quarries.—About one mile south from Corry are two extensive quarries in the summit of the hill just west from the Methodist church; one east from the Corry road owned by Mr. Colegrove, the other west from it and owned by Mr. Heath. Eight feet of the rock is found on the summit, and it has probably suffered some from erosion, as the upper half is so badly shattered that it cannot be used except for riprap or other purposes requiring nothing but rough fragments; the lower half comes in layers 2″ or 3″ up to 12″ thick. The whole bed has a yellowish or buffish-white tinge, is quite hard and tolerably fine-grained. From this locality I have named it the *Corry Sandstone*, and it is identical with the *3rd Mt. Sand* of Mr. Carll. Few fossils occur in it, but in the lower portion were seen a species of *Allorisma*, and *Orthis* and a broad-winged *Spirifer*. *Fucoids* are abundant in the shales above and below the Sandstone.

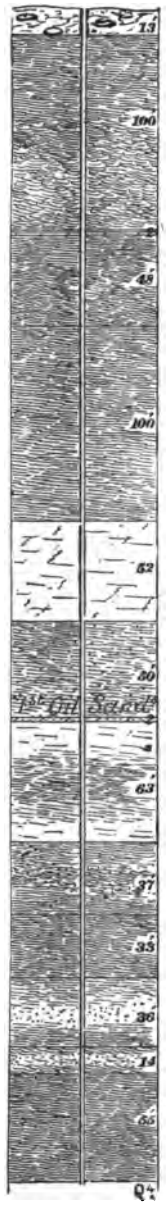
The base of the Corry Sandstone has here an elevation (as closely determined by two rapid drives to and from the Dépot at Corry, one mile away) 1740′ A. T. This would give the horizon of the *3rd oil sand* an elevation here of about 1300′ A. T.

At Union City, 8 miles west, the elevation of the *3rd oil sand* in borings is 1235′ A. T.

Oil wells.—In the vicinity of Corry several deep wells have been drilled for oil without success. Nothing in the shape of records could be obtained.

Gibson & Sterrett's oil well, on their property, in Corry (1545′ deep), commences about 1435′ A. T.—Conductor hole

75.



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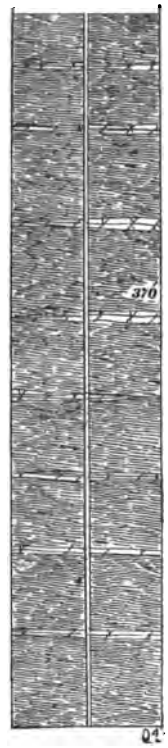

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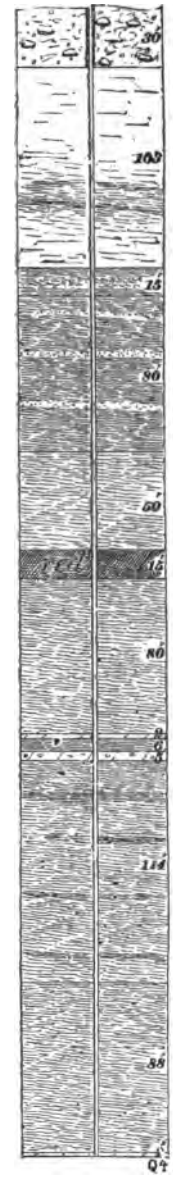


29′ deep; some oil at about 700′.—At Corry the *3rd Oil Sand of Venango* ought to be passed through at a depth of 150′.

Corry and Shenango Sandstones.—About one and a half miles south from Colegrove's quarry, in the *Corry Sandstone*, the surface rises to 1845′ A. T., on the land of Mr. Watson, and the summit is strewn with blocks of the *Shenango Sandstone*, which, however, belong to a somewhat higher bed plane, probably at about 1900′ A. T., since the hills are not high enough to catch the stratum.

As we pass west from Mr. Olmstead's along the road leading to the valley of South French creek, a large stretch of land is seen covered with bowlders of the *Corry Sandstone* at 1700′ A. T.; a few small pebbles occur in it, and the blocks are mostly of small size.

Crossing the south branch of French creek, and ascending the hill southward, we come up to the outcrop of the *Corry Sandstone* at 1685′ A. T.; and above it are occasional exposures of rock; the *Sharpsville Sandstone* is seen on the summit at Blatchley's at 1800′ A. T., all above being concealed by Drift.

About one half mile south from Blatchley's, on the land of Mr. Fralich, a knob rises to 1860′ A. T., and has its summit covered with blocks of the *Shenango Sandstone;* but the horizon of the bed rock is not then reached, since it would probably here come in at about 1900′ A. T. Many *bowlders of granite* are seen lying over the ground in the vicinity of Blatchley's, at 1700′ to 1800′ A. T. None of these knobs seem to be too high for the Drift.

Heath's oil well.—Just south from the cross roads at School House No. 5, a well was dug on the land of Mr. Heath, and a considerable amount of dark and quite heavy oil was found in the crevices of the blue flaggy sandstone through which the well was sunk.

Matterson's quarry.—A short distance north from School House No. 5 we come down to the top of the *Corry Sandstone* at 1700′ A. T. The hard, fine-grained, yellowish white rock is quite massive, in layers 1′ to 2′ thick. It was once quarried here on the land of Mr. Matterson, and enough of

it taken to build a culvert on the P. and E. R. R. near Concord Station. The rock makes a very durable building stone, the only objection being its extreme hardness, rendering it so difficult to dress.

The *Cussewago Limestone* is seen finely exposed along the bed of the little stream just below the *Corry Sandstone.* It is very compact, grayish white, and richer in lime here than I have seen it elsewhere. It breaks with a sharp clear fracture and could be burned into excellent lime. The stratum, 1½′ thick, lies 25′ below the top of the *Corry Sandstone;* or 1675′ A. T.

Near Mr. Darrow's, one mile west from School House No. 5, the surface is covered with yellow *Corry Sandstone* bowlders. The mother rock should be found at this horizon; 1675′ A. T.

Gray's oil well.—One and a half miles northwest from Cooke's P. O. on a branch of Lilley's run, commencing at 1460′ A. T. was 184′ deep, with 50 feet of drive pipe. Several barrels of heavy oil were obtained, and the well abandoned. It still continues to throw out gas and some oil which collects in the pool around the casing and is dipped up for lubricating purposes by the neighbors.

No one could tell me at what depth the oil comes in. Long before any borings were made, the oil flowed out at a spring near the drill hole, and was collected for medicinal purposes.

A short distance west from this the following section is seen in descending a ravine (Fig. 78):

Gray's Run Section.

1. *Corry Sandstone* (at base 1630′ above tide), ... 15′
2. Sandstone, flaggy, and concealed, ... 80′
3. Sandstone, very siliceous, base only seen, ... 1′
4. Sandstone, flaggy, ... 20′
5. Concealed to level of run, ... 75′

The Corry Sandstone No. 1 forms a bluff along the crown of the hill and is quite massive, numerous blocks of it being scattered over the surface.

No. 3 very probably represents the base of the *Cussewago*

Sandstone, the main body being concealed in the interval above.

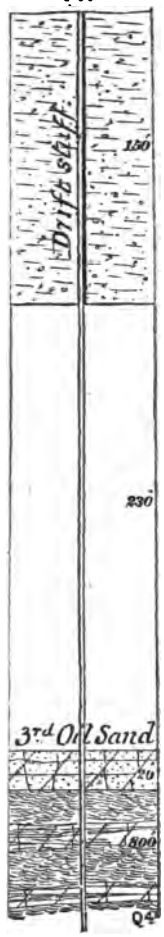
Faye's quarry.—About one and a half miles west from Gray's oil well, and near the western line of the township, we come to some elevated land near Faye's School House, and there on the farm of Mr. Joel Faye the *Corry Sandstone* has been quarried. The bed-rock is not seen, but the surface is covered with blocks of the yellowish-white sandstone, and they cease at 1630′ A. T. A long line of them extends around the hill for more than a mile, and there can be no doubt that the parent bed lies just beneath them. In many places these bowlders completely hide the surface. The mother rock is seen on the land of Mr. Brooks, north from Faye's, and near its base is a very *pebbly layer* containing *flat* pebbles of quartz, some of which are dark, others are green, and of various colors.

Lilly oil well.—About one and a half miles north from Faye's School House, and one mile south from Concord station, on the A. and G. W. R. R., an oil well was once drilled on the Lilley farm by Mr. Price, who gave me the following record of the drilling (Fig. 79):

Lilly well record.

1.	"Drive-pipe," *through Drift*,	119′ to 119′
2.	"Black slate (Big water vein at 123′),"	16′ to 135′
3.	"Blue sandrock, very hard,"	20′ to 155′
4.	"Red rock, blood red,"	18′ to 173′
5.	"Slate, gritty, soft,"	20′ to 193′
6.	"Sharp grit and pebble rock, pebbles thin and flat, some red, dark, and white, pebbly at top, blue grit below," *some oil;* (3rd oil sand—I. C. W.),	25′ to 218′
7.	"Loadstone rock; magnetized the drill; soft like rubber" (!),	90′ to 308′
8.	"Red rock,"	40′ to 348′
9.	"Sand, white, very hard, and filled with pebbles,"	30′ to 378′
10.	"Shells,"	30′ to 408′
11.	"Fine slate,"	100′ to 508′
12.	"Shells,"	35′ to 543′
13.	"Sand, white, very hard, some pebbles, *big gas vein* near center,	25′ to 568′
14.	"Gritty slate,"	60′ to 628′
15.	"Red rock,"	5′ to 633′
16.	"Shells,"	67′ to 700′
17.	"Slate, with no grit,"	90′ to 790′
18.	"Shells, very hard to bottom of hole,"	55′ to 845

77.



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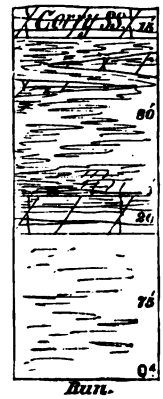

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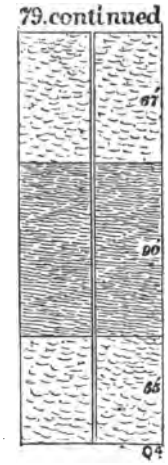

"In No. 6 some oil was obtained, dark-green in color and rather heavy."

"In No. 13 a great gas vein was struck; threw water over top of derrick."

The well commences 3′ above level of Lilley's run, and closely determined by checking twice at Concord Station, one mile north, at 1375′ A. T.

No. 6 would represent the *3rd oil sand*, since Mr. Price's description of it answers very closely to the structure of this rock at many localities in Erie county; and it comes at about the right depth below the *Corry Sandstone.* The base of the Corry Sandstone, 1½ miles further south, is found at 1610′ A. T. Therefore, estimating the northward rise at about 20′ per mile, at 1640′ A. T. or (1640′—1375′=) 265′ above the mouth of the well; therefore (265′+193′=) 458′ is the interval between the base of *Corry Sandstone* and No. 6 of the well; the average interval between the *Corry* (3rd Mt.) *Sandstone* and the *3rd oil sand* being say 450′.

The great depth of Drift here is the more remarkable, seeing that within 3 rods of the drill hole the bed-rock crops out on the west bank of the run. This place is one mile from French creek; and immense heaps of *Drift* are seen on both sides of that stream for a long distance back, usually one to two miles.

Barometric levels in Concord.

Forks at Faye's School House,	(above tide,)	1640′
" near H. Cooke's,	"	1480′
Level of Lilley's run at saw mill,	"	1372′
Forks near H. Parson's,	"	1395′
" " E. A. Hammond's,	"	1465′
Cross roads near D. Lewis's,	"	1580′
" " R. Darrow's,	"	1710′
" " School House No. 5,	"	1745′
Forks at south line of town'p near C. H. Webber's,	"	1705′
" near Mrs. Higgin's,	"	1595′
Crossing R. R. near J. Bell's,	"	1610′
Forks near S. Blatchley's,	"	1800′
" " J. H. Moffat's,	"	1500′
" " B. Davis,	"	1725′
" " School House No. 7,	"	1710′
" " H. Corry's,	"	1725′

Forks near W. W. Covell's, ...	(above tide),	1535′
R. R. Crossing West, ...	"	1485′
Forks near School House No. 8, ...	"	1585′
" " Mrs. Blakeslee's, ...	"	1650′
" " Town House, ...	"	1530′
Cross roads at Lovell's Station, ...	"	1375′

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36. *Union, in Erie county.*

This lies directly west from Concord, and also adjoins the Crawford county line.

It is drained by the South Branch of French creek which flows west nearly through its center, receiving many small tributaries from both north and south. It thus forms a kind of basin, with a divide on its northern border separating its drainage from the waters of Le Bœuf creek, and one on the south between Oil creek and French creek proper.

There is a very wide valley along South French creek, everywhere filled with Drift.

The aspect of this valley would lead one to believe that it possessed a very deeply buried rock bed, but so far as the borings of numerous oil wells have determined the matter no deep valley has been found, but bed-rock is invariably obtained a few feet below the level of French creek.

At Union City several wells have been bored for oil.

One *Union well* was bored just south of the A. G. W. R. R. dépot and at the same elevation (1301′ A. T.) It struck a pebble rock at a depth of 70′ which yielded some oil. The pebbly portion was 5′ thick, and this represents the *3d oil sand*, since its top would come at 1301′—70′=1231′ above tide, and the top of the *3d oil sand* at the Carroll quarries, 3 miles due west is found at 1220′ above tide, thus proving that the two are identical, since there is not much change in level of the rocks in going east or west, in this region. The well was drilled to a depth of 200′ but no oil was found below the 70′ horizon.

Another *Union well*, on the opposite side of French creek, and a short distance above the P. and Erie R. R. dépot, was bored, commencing at 1265′ A. T.

No record was preserved, but one of the drillers gave me the following items concerning it from memory:

"Conductor hole 16′ in depth."

"Well drilled to 1600."

"At 800′ struck a sand and such a quantity of gas as to drive the men away from the derrick."

"No oil show of any consequence. Most of drilling through soft slate, with occasional hard shells."

At Union the bed rock is seen along French creek, and it consists of a blue shale alternating with thin sandy layers.

South from Union City one mile, the base of a somewhat massive sandstone is seen at 1500′ above tide and it continues in flaggy layers 1′—2′ thick up to the top of the hill 40′ above. This comes at the horizon of the *1st Oil Sand of Venango*, and it is doubtless the representative of that stratum, since it comes about 1500′—1230′ = 270′ above *3rd Oil Sand* struck in the boring one mile north at Union City.

The *Drift* covers up everything so effectually in this township that its rock structure is nowhere extensively shown. The *Corry Sandstone* is however about the highest stratum found along its southern border, while at its western limit French creek cuts down to the *3rd Oil Sand* thus giving a vertical range of 450′ in the strata above water-level.

Barometric elevations in Union.

Forks of road near School House No. 4, ...	(above tide,)	1545′
" " " W. Shepard's, ...	"	1625′
" " " W. Carter's, ...	"	1470′
" " " J. Sill's, ...	"	1460′
" " " E. Matteson's, ...	"	1510′
" " " B. E. Reynold's, ...	"	1460′
" " " J. Devereaux's, ...	"	1450′
Level of Pine run near A. White's, ...	"	1385′
Forks of road near A. B. Stanton's, ...	"	1465′
" " northeast from J. J. Lyon's, . . .	"	1470′
" " near A. Clark's, ...	"	1510′
Summit near D. Hubbell's, ...	"	1570′
Forks of road near J. E. Fenno's, ...	"	1365′
" " " J. Meehan's, ...	"	1435′
Cross roads near S. Bemas's, ...	"	1520′
Forks near N. Rockwood's, ...	"	1595′

37. *LeBœuf, in Erie County.*

This lies west from Union, having Waterford township on the north, and Crawford county for its southern boundary.

The drainage is carried off by French creek and its tributaries. The north and south branches of French creek unite near the northeastern corner of the township, and flowing west with many windings both north and south, it receives LeBœuf creek near the western line, and there turning abruptly south continues in that direction until it passes out of this county into Crawford.

A very wide Drift-filled valley is found all along French creek, but no evidence of a deeply buried valley was obtained simply from lack of borings or explorations. It is not probable that a deeply buried valley will be found along French creek, in this township, before the mouth of LeBœuf creek is reached, since above this the bed-rock is often seen in the stream, and then the borings that have been made along the valley disclose no buried channel of any considerable depth.

This township is most interesting in its geology, since within its borders we get the first peep at the *3rd oil sand of Venango*, that famous depository of *petroleum*, the continued northward rise of the strata having at last brought this rock above water level along French creek.

The *3rd oil sand* has long been quarried on the left bank of French creek, one mile southwest from LeBœuf Station. The locality is known as the Carroll quarries.

The following succession is seen in descending from the quarry across the A. &. G. W. R. R. to French creek (Fig. 80):

Carroll quarry.

1. Shales,			6′
2. *Spirifer Band*,			1′
3. Shales,			8′
4. *3rd oil sand*,	1. Pebbly rock,	7′	15′
	2. Blue sandstone,	8′	
5. Blue shale to level of French creek,			15′

No. 2 is a mere mass of shells, all of Chemung type, and the predominant species is *Rhynchonella contracta*, Hall, in very fine state of preservation. *Atrypa hystrix* is also quite abundant, as well as broad-winged Spirifers of the type *S. disjuncta*. A large *Discina-shaped* shell was also seen.

The upper portion of the *3rd oil sand*, No. 4, is a mere mass of pebbles, among which occur jasper, white, green, and smoky quartz. The pebbles are all worn smooth, and are very thin and *flat*, some being 2″ long by 1½″ wide and half an inch thick in the middle while tapering to almost a knife-edge at the margin.

The pebbly portion is saturated with oil in many places, and often in quarrying the workmen tell me that they find plenty of oil in the crevices of the rock between the joints; occasionally as much as two or three gallons of very heavy oil has been collected, where some of the bottom layers of the rock were taken up. Every portion of the rock, both the pebble and the quarry stone, has a distinct smell of *petroleum*. The upper or pebbly half of the stratum is of course worthless, and its removal largely increases the cost of mining; it passes without any distinct dividing horizon into the quarry sandstone below, which is quite homogeneous and free from pebbles. The pebbly portion has not always the same thickness however, but runs up and down in a very irregular way and at the expense of the sandstone below.

The lower half of No. 4, or the quarry portion is a tolerably fine-grained bluish-gray sandstone found in layers 1′ to 2′ thick. It splits readily, dresses easily and when not containing too much oil, makes a valuable building stone. It has long been shipped to Erie from Le Boeuf Station on the Phil. and Erie R. R. where it is extensively used for door sills, stepping stones &c. The bottom layer of the stratum, where exposed along the French creek bluff, a short distance below the quarry, is covered on its under-side with the furrowed stems of *Crinoids;* and in one of the quarry layers was seen a small vertically-stemmed *Fucoid*. Many

shells and also fragments of wood are found in both the pebbly and quarry portions of the stratum.

The blue shale, No. 5, under the *oil sand* is very soft and fine; it contains no remains except *Fucoids* so far as seen.

The top of *the 3rd oil sand* is here at 1220′ A. T.

Should it be asked why I am so confident that this *Carroll quarry rock* represents the *3rd oil sand of Venango*, I have to say that the whole section has been carried bodily northward from the southern line of Crawford county; and a sandstone with an underlying limestone (Corry and Cussewago) have been traced continuously into Erie county, and certainly identified. Now this *Corry sandstone* (3rd Mt. when carried here on the observed dips both from the east at Corry, and from the south where it is last seen near the northern line of Crawford would have at the Carroll quarries an elevation of about 1660′, making an interval of 1660′ —1220′=440′ between the Corry SS. (3rd Mt.) and the Carroll quarry rock, which is of course sufficient evidence that the latter comes at the horizon of the *3rd oil sand of Venango.*

Canty's quarry.—Half a mile above the Carroll quarry, Bailey's run puts into French creek. Where the public road crosses the south branch of the same, the *3rd oil sand* is finely exposed in a cliff over which the water makes a fall of 10 feet. The stratum shows very much the same structure here as it does at the *Carroll quarry*, and has also been quarried by Mr. Canty. The upper half is very pebbly, and is filled with vegetable remains, in fact it is a regular buried forest of ancient vegetation, consisting of trunks and branches of trees, the carbonaceous part of which has apparently been converted into oil since the rock is saturated with it, and the cavities containing the original woody matter are now filled with a soft mushy residuum from the evaporated *petroleum*, and remnants of cellular tissue just like rotten wood, smelling strongly of oil and frequently saturated with it. Occasionally a film of *coal* is seen on the outer surface of a fragment of wood. Petroleum is continually seen floating over the water at the base of the sandstone.

Singer's boring.—Just west from this quarry, and 20′ lower

than its top, an oil well was bored on the land of Mr. Singer to a depth of 780′. No record could be obtained, but a man who worked at the well told me it was soft drilling all the way and that a big gas vein was struck at a depth of 500 feet.

About one and a half miles northeast from this last locality, in the angle between the north and south branches of French creek, the *3rd oil sand* is seen in a bluff along the hillside, its base having there an altitude of 1240′ above tide. Here at a spring which issues from beneath the *3rd oil sand* oil has been collected for a long time, and its presence induced a company to bore for oil just above it, on the land of Mr. Moore.

Moore's borings.—Two wells were put down, one starting immediately on top of the *3rd oil sand* at 1252′ above tide, and the other further up the hill at 1290′. No oil of any consequence was found in either though in the last one a considerable "show of oil" was obtained at a depth of 45′ where the *3rd oil sand* was struck. Mr. Moore says, that a *sandrock* was also struck 60′ below the *3rd oil sand* and considerable gas was obtained in it, and also a slight show of oil.

The *3rd oil sand* goes under French creek about one and a half miles below Carroll's quarry, and is seen no more to the south along that stream.

West from French creek, the surface rises along the western boundary of the township to an elevation of 1550′ above tide, and frequently catches outcrops of the *1st oil sand*, as well as higher members of the *Barren group* above.

Near Mr. Estel's the outcrop of a flaggy and sometimes massive sandstone is seen at 1525′ above tide; some of the layers have been quarried, and they make excellent flagging when not too thick.

The following list of Barometric elevations was made in Le Boeuf:

Mill Village Cross roads, ...	(above tide,)	1215′
Forks of road near P. H. Colt's, ...	"	1255′
" " " School House No. 6, ...	"	1550′
" " " Mrs. Frisbee's, ...	"	1495′
Cross roads east from Edenville P. O., ...	"	1570′

Cross roads near Mrs. Bice's,	(above tide),	1280′
Forks of road north from A. S. Colt's,	"	1240′
Level of French creek at Carroll's quarry,	"	1190′
Forks east from Le Boeuf Station,	"	1240′
" near Stranahan's,	"	1220′
Cross roads near H. Port's,	"	1195′
Level of Le Boeuf creek next west,	"	1185′
Forks near A. Lehentaler's,	"	1375′
" " J. W. Hunter's,	"	1215′
" " A. Bishop's,	"	1510′
" " E. Estel's,	"	1530′
" " H. Mourass's,	"	1195′
Level of French creek at bridge west from Mill Village,	"	1165′
Forks near J. Asher's,	"	1225′
" next south,	"	1290′
" near J. Walker's,	"	1475′
" " M. Babbett's (at Town'p line,)	"	1375′
" " J. Dun's,	"	1175′
Cross roads near G. Berger's,	"	1175′

38. *Washington, in Erie County.*

This lies directly west from LeBœuf, having Crawford county for its southern boundary, and McKean township for its northern.

Its drainage all passes southward except a small area along the northern border, which sends its water northward into Lake Erie.

The two principal drainage streams are Conneautee and Little Conneautee creeks, which empty into French creek very close to each other in Crawford county. Both flow through old Drift-filled valleys with a very sluggish motion.

A little south from the central line of the township Conneautee creek expands into a broad sheet of water called *Conneautee Lake*, which, in summer time, is covered with a dense growth of water lilies (*Nymphaea odorata*). The surface is almost completely covered up with Drift, so that but few rock exposures are to be seen; nevertheless, it is certain from what is known of the geology in contiguous areas that the *Oil Sand Group* forms the underlying rock above drainage all over the township, the streams not cutting down quite to the *3rd Oil Sand* at any locality.

At the eastern line of the township, near Mr. D. Goering's, the following is seen in descending along the road (Fig. 81):

Goering's section.

1. Sandstone, seen, ... 10′
2. Shales, sandy, ... 45′
3. Flaggy sandstone, ... 10′
4. *Spirifer Band* (elevation 1345′ above tide), ... 1′

No. 1 is rather massive and white, with a fine-grained texture; probably one of the *Upper Oil Sands.*

No. 3 is a chocolate color, and has been quarried along the road.

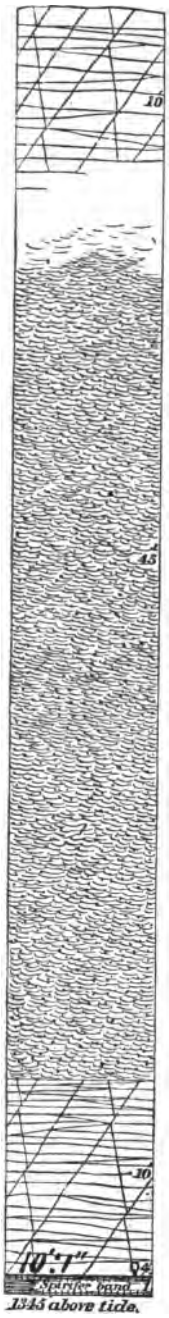
Immediately below it is seen a *Spirifer Band*, wholly made up of shell remains, among which *Spirifers* predominate; at the outcrop of the rock all the lime has been leached out by atmospheric agencies, leaving nothing but the porous, soft, insoluble impurities. This *residuum* has a darkish-brown color, and retains the casts of shells very distinctly; these fragments are frequently found commingled with the Drift as far south as those deposits extend. A few inches in from the surface of the stratum, however, it is very hard and limy.

Comer's quarry.—On a branch of Little Conneautee, which puts into that stream at Roach's Steam Mill, a sandstone has been quarried on the land of Mr. Harry Comer.

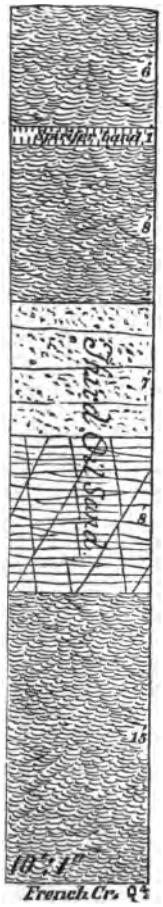
The stratum is 12′ thick, and its base is found at an elevation of 1335′ above tide. The rock is of a grayish-white color, tolerably hard, and smells strongly of *oil.* It passes into shelly layers above, and below it come blue shales. This comes at about the right horizon for the *2nd oil sand*, and it most probably represents that stratum.

Anderson's quarry.—About one mile west from Edinboro', near Hotchkiss' cross-roads, a sandstone has been quarried on the land of Mr. Anderson; its base is 1425′ A. T., and about 5′ of the rock is taken out. It smells of *petroleum*, and is a perfect mass of *Fucoids*, especially between the layers. The rock is of a bluish-white color, very hard, and makes a rather inferior building stone, since the layers are only 4″ to 6″ thick. Near its base is seen a coarse,

81.


10
15
30
10'-1"
Q2
Spirifer band
1345 above tide.

80.


6
8
Third Oil Sand
7
8
15
10'-1"
French Cr. Q2

83.

fucoidal sandstone
10
12
quarry rock of 3rd Oil Sand.
8
10
fucoidal sandstone
8
10'-1"
Q4

pebbly layer, which rapidly disintegrates on exposure into a heap of loose sand. This quarry rock most probably represents the *1st oil sand*, since it comes at the right elevation for that horizon.

Barometric elevations in Washington.

Forks of road near D. Goering's,	(above tide,)	1360′
" " " E. Ryan's,	"	1250′
" " " R. Stilwell's,	"	1300′
Level of Little Conneautee, just west,	"	1205′
Cross-roads next west,	"	1220′
Forks of road near T. G. Stafford's,	"	1220′
Cross-roads near W. McClelland's,	"	1220′
" " A. Culbertson's,	"	1225′
Level of Little Conneautee just west,	"	1180′
Cross-roads at School House No. 14,	"	1190′
" near H. McClelland's,	"	1455′
Forks near H. Herbert's,	"	1225′
Cross-roads near M. S. Hawkin's,	"	1205′
" " Fulling Mill,	"	1200′
" one mile west from Edinboro',	"	1455′
Forks near N. Shields',	"	1450′
Cross-roads near School House No. 12,	"	1380′
" " " No. 11,	"	1470′
" " I. Logue's,	"	1350′
Forks near G. McGahan's (N.E. from Edinboro'),	"	1450′
Cross-roads near Roach's Mill,	"	1270′
Forks near W. Ash's,	"	1360′
Cross-roads near School House No. 9,	"	1565′

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39. *Franklin, in Erie county.*

This lies directly northwest from Washington and adjoins it on the east and south.

The township lies on the divide between Lake Erie, and the southward flowing waters, so that most of its drainage goes northward by small streams which cut down often 200′ to the mile, before they enter Elk creek which flows just north from this area. In this way very satisfactory sections of the strata below the *3rd oil sand* are exposed.

Howard's quarry.—In the northeast of the township, within 8 miles of Lake Erie, a bed of sandstone has been mined for a long time at what is known as Howard's quarry, or the village of Stone Quarry. This important horizon was

certainly and distinctly identified with the quarry rock near Le Bœuf, and thus with the *3rd oil sand.* The identification was made both by carrying the stratum along with the stratigraphy, and also by a *peculiar* assemblage of *fossils*

82.

89.

found at every quarry on this stratum in Erie county, and in no other rock either above or below it. The lithology of the rock also serves to identify it, since it differs decidedly from all others in the series.

Falls run flows northward past Howard's quarry, and cutting down very rapidly through the soft measures underlying the *3rd oil sand*, exposes the following excellent section before it joins Elk creek two miles to the north: (Fig. 82.)

Fall's run section.

1. Hard Fucoidal SS.,	5′	
2. Shales and flaggy SS.,	10′	
3. Sandstone, quarry rock,	4′	*3rd oil sand*, 37′
4. Shales,	10′	
5. Hard Fucoidal SS.,	8′	
6. Blue shales with thin sandy layers,		25′
7. *Spirifer band*,		1′
8. Somewhat massive sandstone,		15′
9. Shales,		15′
10. Flaggy sandstone,		15′
11. Sandstone and spirifer beds,		12′
12. Blue shales,		20′
13. *Spirifer band*,		1′
14. Flaggy sandstone,		15′
15. Blue fossiliferous shale,		50′
16. Flaggy sandstone,		15′
17. Blue shale,		3′
18. Flaggy sandstone, massive at base,		15′
19. Blue shales, with fossils,		10′
20. Flaggy sandstone,		10′
21. Shales and flaggy sandstone,		65′
22. Limestone,		1′
23. Blue shales with no sandy layers to level of Elk creek,		100′

I have included in the *3rd oil sand* Nos. 1 to 5, though in reality No. 3 is the characteristic portion of the stratum both in lithology and fossils, and is the rock that has here been quarried so extensively. It is bluish-gray in color, and of tolerably fine texture, coming in layers ½′ to 1½′ thick; splits easily, dresses well and makes a very fair building stone. It has been hauled to a long distance into the surrounding country for this purpose. The rock smells strongly of *petroleum*, and in many places is saturated with it to such an extent as to render the courses in which the oil occurs, unfit for building purposes. The stratum is also very *fossiliferous* containing the remains of both mollusks and fucoids in great quantities the former at times in such numbers as to make an impure *limestone* layer near the center of the stratum. The shells are preserved in remarkably fine condition, and a representative collection was made at the locality from which Profs. Whitfield and Stevenson have kindly identified for me the following:

Productella Sp.?
Chonetes Illinoisensis.
Streptorhynchus Chemungensis.
Spirifera aspera.
Rhynchonella contracta.
Edmondia Burlingtonensis.
Grammysia Hannibalensis.
Aviculopecten Sp.?
Pleronites Sp.?
Goniophora aeola.
Goniophora rigida.
Platyceras paralium.
Orthoceras Sp.?
Bellerophon Sp.? (See Part I, page 110.)

These eminent authorities remark in connection with this list that "they represent a horizon well down in the *Chemung*, and if the rocks in which they occur be not Chemung then there is no *Chemung* anywhere."

In addition to these I have seen *Euomphalus depressus*, Hall, page 291, Geology of 4th District, New York, at the Howard's quarry, as well as at many other localities on this horizon in Erie county, and since this shell occurs in the Panama Conglomerate, it is additional evidence that the latter stratum is identical with the *3rd oil sand of Venango*, which I have proven on stratigraphical evidence in another portion of this Report.

This list of fossils, though probably not quite so full at other localities, is seen in connection with the *3rd oil sand* at every quarry on the horizon in Erie county, and serves at once as an important check on the stratigraphy, since the grouping is peculiar to this horizon.

It is possible that some of the *oil* found in this stratum, No. 3, has been derived from the molluscan remains with which it is filled, since Mr. Howard tells me that he has often in quarrying broken open shells which contain several drops of oil in a central cavity; but it is possible that the oil may have percolated into the cavities of the shells from the enclosing rock, instead of originating from decomposi-

tion of the animal organisms themselves, although the probabilities are in favor of the latter hypothesis.

But if none of the oil in the rock at the Howard quarry has been derived from the heaps of shell-remains entombed, there remains yet one other possible source for its genesis within the containing rock, viz: from the millions of sea-weeds which have been enclosed in the same stratum; they are mostly cylindrical, or rather have been so, but they are now flattened by pressure. In some parts of the quarry they occur in such quantities as to spoil the rock for building purposes; they are of all sizes and shapes, usually not more than 1″ in diameter, and crossing each other in every direction.

Mr. Leo Lesquereux, the eminent Palæobotanist of Columbus, Ohio, several years ago proposed the theory of the origin of petroleum from sea-weeds, (see Report of Progress J, pages), and the abundant occurrence of these remains in connection with so many localities in Erie county where the *3rd oil sand* is saturated with oil, lends great probability to this theory, and especially when they are often the only vegetation entombed in the rock.

Nos. 1 and 5 are rocks very much alike in aspect; both are very hard, rough-looking sandstones, and are indented on their upper surfaces with multitudes of vertically-stemmed *Fucoids*, and these weathering away more rapidly than the matrix, have left the upper surface of the stratum perforated with holes.

No. 5 is quite massive, and the water of the stream, after running along on its top for a considerable distance, suddenly plunges over a precipice with a vertical fall of 60′ through the softer underlying rocks.

Nos. 7 and 13, as well as several streaks in No. 11, are so full of shells that they would make regular limestone layers, only that the tests of the Mollusks are only partially comminuted, and thus stand out quite prominently, giving the blocks a rather forbidding aspect.

No. 15 is somewhat fossiliferous, containing *Atrypa*, *Orthis*, *Rhynchonella*, and others.

After we pass below this in the rocks, the fossils gradu-

ally disappear, and when we come down to No. 23 not a trace of animal remains is to be seen, and the rocks are totally non-fossiliferous, with the exception of *Fucoids*, which seem to be as abundant as ever.

This series of flaggy sands and shales from Nos. 6 to 22, inclusive, constitute a well-defined group of rocks, both lithologically and palæontologically. Failing to find any suitable geographical name, I have termed them provisionally the *Chemung Flags*. The thickness of this subdivision at this locality, after making allowance for a northward rise of 40′ in the two miles from Howard's quarry to Elk creek is about 325′; and this holds at other localities in the county, except that the group seems to thicken slightly toward the east. A list of the fossils recognized in the *Chemung Flags* is given in the summary of this Report.

No. 23 is the upper portion of a series of ashen-gray shales, which are finely exposed along Elk creek between this point and the town of Girard, and from this fact I have termed them the *Girard Shale*. The whole formation is remarkably uniform in structure, being composed throughout of a very argillaceous ashen-gray shale, which is exposed in long lines of cliffs which from a distance look like heaps of gray coal-ashes. The thickness of the entire formation is about 225′, so that at the mouth of Falls run 125′ of it lie below drainage. These shales are exposed along every stream that puts into Lake Erie; and in the hundreds of times I have seen them exposed I have never seen any fossils in them except *Fucoids*. I regard them as the *transition series* from the *Portage* to *Chemung*, since at their bottom comes undoubted *Portage rocks*, and in the series above No. 23 are typical *Chemung fossils*.

Howard's borings.—At the foot of the "Falls," just below the quarry Mr. Howard sunk a well to a depth of 150′ in quest of oil, but none was obtained.

A short distance south from the quarry, on the land of Mr. Henry Howard, another well was drilled to a depth of 250′, commencing above the *3rd Oil Sand;* some oil was obtained in it at a depth of 35′, but none in the rocks below.

Goodban's quarry.—About one mile N. E. from Mr. How-

ard's the *3rd Oil Sand* is quarried on the land of Mr. Goodban, along another stream which flows northward parallel to Falls run, and the following succession is seen (Fig. 83):

Goodban's quarry.

1. Hard Fucoidal S. S., ... 10′
2. Shales, ... 12′
3. *Quarry S. S.*, ... 8′
4. Shales, ... 10′
5. Hard Fucoidal S. S., ... 8′

Here the section is quite similar to that seen at Howard's quarry, except that No. 3 the quarry rock is somewhat thicker. The stone smells strongly of petroleum, and the quarrymen told me that they often found considerable quantities of it in the crevices at the bottom of the stratum. Many fossils are seen in the rock at this locality, but not so many as at Howard's.

Nos. 1 and 5 are very much alike in every way; both are buff-colored, very rough-looking, and quite siliceous; both also are filled with vertically-stemmed *Fucoids*, which, weathering away faster than the containing matrix, leaves the top of the rock full of holes and protuberances. While many of the *Fucoids* have the stems running vertically, a great many others lie flat in the rock, their tangled masses crossing each other in every direction.

The base of No. 3 comes here at 1170′ above tide, or 20′ higher than at Howard's quarry.

Waxham's quarry.—A mile N. E. from Goodban's, the *3rd Oil Sand* is quarried in the edge of Franklin, on the land of Mr. Waxham, where the quarry portion is 4′ thick, and contains much petroleum, which floats out on the water at its base. The elevation of the stratum is 1190′ A. T.

Reed's quarry.—East from this a short distance the same rock is quarried on the land of Mr. Reed, where the rock shows a face of 8′ in layers 1′–1½′ thick.

Barometric elevations in Franklin.

Cross-roads near Robinson's S. Mill, ...	(above tide),	1350′
" " School House, next west, . . .	"	1300′
Forks near A. Mead's, ...	"	1270′
Cross-roads at P. O., ...	"	1240′

Crossing of Falls run next north, ...	(above tide),	1180′
Forks near L. Howard's, ...	"	1175′
Crossing of Falls run at stone quarry, ...	"	1140′
Forks near J. Hartman's, ...	"	1180′
Cross-roads near Mrs. Goodban's, ...	"	1250′
" " T. Spencer's, ...	"	1275′
Forks near J. Clapper's, ...	"	1270′
Cross-roads next east (at Township line), . . .	"	1310′
" near M. Vanbuskirk's, ...	"	1120′
Forks near N. Coburn's, ...	"	1025′

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40. *Elk Creek, in Erie County.*

This area lies southwest from Franklin, and has Crawford county for its southern boundary.

Its northeastern portion drains northward into Elk creek, and its southeast part sends its waters south by way of Cussewago into French creek, while the western portion drains into Conneaut creek, and thus northward into Lake Erie.

The surface rocks of this township belong almost entirely to the *Venango Oil Group*, except along the northern and western portions, where the northward flowing streams have cut down below the *3rd Oil Sand* and exposed the *Chemung Flags*.

Crane's quarry.—The *3rd oil sand* was once quarried about 3 miles east from Cranesville along a small stream which flows northward. The locality is on the land of Mr. Crane, at his mill. The quarry rock is about 6′ thick and its base is, by careful barometric measurement twice checked, 1075′ above tide, or 75′ lower than the same rock at Howard's quarry in Franklin township 4 miles northeast, thus showing a dip of near 19′ to the mile toward the S. S. W.

Crane's quarry was once extensively mined by the Beaver and Erie Canal Co., and used in building their locks. The stone was taken down Elk creek on a tram railroad. The stratum is in layers 1′–2′ thick, and has the same bluish-gray color, and general facies as this rock at Howard's quarry. It also smells strongly of petroleum, and the oil collects on the water at the bottom of the quarry.

The shaly portions of the rock are filled with millions of

Fucoids whose long tangled stems cross and re-cross each other in every direction.

Along the stream below the quarry, at Crane's, we see the hard silicious layers observed in Franklin, filled with vertically-stemmed *Fucoids*.

Flagstone.—At Wellsburg, ½ mile S. from Cranesville, we come down to a horizon 140′ below the *3rd oil sand*, and there find some hard blue layers of flaggy sandstone which are very fossiliferous and have been quarried to some extent for flagging in the bottom of the little run at the upper end of the village. These rocks belong to the *Chemung flags*.

Reynold's quarry.—At the very eastern line of the township, Mr. Reynolds has a quarry in a grayish white flaggy stratum at 1300′ above tide. It belongs to the *oil sand group*.

The following list of barometric elevations was made in Elk Creek township.

Cross roads at eastern line of township near Mrs. Sherrod's,	(above tide,)	1380′
Level of Cussewago to the west of Mrs. Sherrod's,	"	1200′
Forks near W. H. Vandyke's,	"	1290′
Cross roads near J. McCommon's,	"	1170′
" " A. J. Campbell's,	"	1200′
" " J. T. Thompson's,	"	1100′
Forks near H. Sherman's,	"	930′
" at cemetery below Wellsville,	"	955′
Cross roads at Cranesville,	"	955′
Forks near D. Lander's,	"	1100′
Cross roads near J. O'Brien's,	"	1135′

41. *Conneaut, in Erie county.*

This township occupies the southwest corner of the county along the Ohio line between Crawford county and Conneaut creek.

It is drained entirely by Conneaut creek, which flows north through its eastern margin, bends sharply west, forms its northern line, and passes into Ohio, on its way to Lake Erie.

The whole township is one bed of Drift, which buries the rocks so deeply that the streams seldom cut down to the

rock strata concealed beneath it. Occasional exposures, however, show that all the hills are too low to catch the *Third Oil Sand;* and that all the surface rocks of the township are *Chemung flags;* Conneaut creek not cutting quite down to the *Girard Shale.*

At the bridge-crossing of Conneaut creek, near Mr. Griffy's, below Cherry Hill P. O., the following section is seen in the bluff (Fig. 84):

Griffy's Section.

1. Blue shales, ... 12′
2. Sandy flags to water-level, ... 4′

A layer of shale near the base of No. 1 contains numerous fossils, which very much resemble *Avicula fragilis,* Hall.

Conneaut creek here flows on a rock bottom (212′ above Lake Erie) 785′ A. T.

Barometric elevations in Conneaut.

Level of Conneaut creek west from Albion Station, ...	(above tide),	815′
Forks of road near J. H. Silverthorn's, ...	"	855′
Cross-roads near V. Forbes', ...	"	850′
" next west, ...	"	885′
Forks near G. Spaulding's, ...	"	890′
Cross-roads near P. M. Keep's, ...	"	930′
" next west, ...	"	940′
" near D. Thomas', ...	"	945′
" " H. Huntley's, ...	"	925′
" " B. Griffy's, ...	"	925′
Level of Conneaut near W. Griffy's, ...	"	785′

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42. *Springfield, in Erie County.*

This township lies along the Lake Shore, next the Ohio line.

Its southern portion on the bluff above Conneaut creek has an elevation of 850′ to 900′ A. T., but gradually declines northward down to the Lake Shore bluffs, whose altitude here ranges at about 625′ A. T. The western end of the township drains into Ohio. Raccoon and Crooked creeks

rise on the southern highlands and flow north into Lake Erie.

The township is everywhere buried so deep beneath the *Drift* that the streams have seldom cut through it. Except along Conneaut creek, at the south township line, and at one locality on the Lake Erie Shore, I could see no rock exposures in the entire area. Even along the Lake Shore, where the cliffs of gravel and glacial débris are being constantly washed away, not a single stratum of bed-rock is to be seen, except at the one point referred to.

In descending from the south to the lake, several wide level benches are noticeable, covered with a thick deposit of sand, no doubt marking the former higher level of the lake; but no successive well-marked terraces can be made out in this township; probably because they have suffered so much from erosion as to be unrecognizable.

Griffith oil boring.—At the southern line of the township a well was once bored for oil on the land of Mr. Wm. Griffith, commencing near the level of Conneaut creek, and passing through the following rocks, according to the statement of Mr. Griffith (Fig. 85):

Griffith oil well record.

1. "Conductor," . . . . . 7′
2. "Blue rock" to bottom, ... 323′

"Soft water at 75′, and small gas vein at bottom; threw water out of the hole 10′. No oil was obtained."

Rand oil boring.—Another well was drilled two miles northwest from this, on the land of Mr. Rand, to a depth of 400′, but no oil was found.

The underlying rocks in this township belong to the lower half of the *Chemung flags*, and to the *Girard shale;* the latter extending to the lake shore. If the Drift could be removed from the northeastern half of the township along the lake shore we should see the top layers of the *Portage* rising from the level of the lake near the mouth of Raccoon creek, two miles east of the Ohio line; for, at the mouth of Crooked creek, the top of the *Portage flags* are visible 15′ above lake level = 588′ A. T.

Barometric elevations in Springfield.

Forks of road near A. E. Crouch's (near southern line of T.),	(above tide),	850′
Cross roads at H. M. Devereaux's,	"	855′
" near J. Weldon's,	"	765′
Forks in West Springfield,	"	720′
" at A. J. Freeman's,	"	700′
" near I. A. Benedict's,	"	675′
" near J. C. Kirkland's,	"	675′
Crossing of Lake Shore R. R. north,	"	650′
Forks next north,	"	640′
" at Ohio line near N. Blickensderfer's,	"	640′
" next north near the lake shore,	"	625′
Cross road near G. B. Webb's,	"	600′
Forks near J. Eagley's,	"	625′
" C. Eagley's,	"	640′
Crossing of Lake Shore R R. near J. Brake's,	"	655′
Cross roads near R. Hall's,	"	660′
" " M. Mallory's,	"	675′
Forks near S. Ivory's,	"	705′
" A. Mallory's,	"	680′
" A. M. Moon's,	"	710′
" J. Morgan's,	"	725′
" C. H. Baldwin's,	"	745′
Cross roads at Springfield P. O.,	"	740′
Forks next north,	"	730′
" near J. M. Strong's,	"	725′
Cross roads near P. Ellis',	"	705′
Forks in North Springfield,	"	660′
Forks near Halliday's saw mill,	"	605′
" Mrs. Whitley's,	"	655′
" G. W. Brindle's,	"	690′
" H. Dixon's,	"	710′

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43. *Girard, in Erie County.*

This township, along the Lake Shore, is traversed from its east line to its northwest corner by Elk creek, a large stream, with Brady's run coming in from the northeast, the South branch coming in from the south, and another branch from Elk Creek township.

The surface is broken and uneven; the streams from the south descending from highlands with a rapid fall, and excavating deep channels (through *Drift*) into the underlying strata.

Elk creek trenches a deep and narrow channel into the rock strata clear across the township, exposing the structure in a splendid manner; bluffs 100′ high often bordering the stream.

The rocks of the township belong to the *Chemung flags*, the *Girard shale*, and the *Portage flags*. The latter comes along the lake shore and extends up the streams for a short distance.

The *Girard shales* are exposed all along Elk creek as a series of bluish or ashen-gray shales, remarkably uniform, and singularly destitute of any organic remains save *Fucoids*, which occur in abundance.

Very few sandy layers occur in the series, which consists of finely laminated slate and clay layers. These line the streams in vertical cliffs, and from a distance look like huge heaps of gray coal-ashes.

In the southern portion of the township, where the road crosses the south branch of Elk creek, near Mr. Babbits', along a ravine descending to the creek, the following section shows itself (Fig. 86):

Babbit's Section.

Sandstone, seen,	3′
Shale, *fossiliferous*,	0′ 6″
Shaly sandstone,	15′
Blue shale,	20′
Shaly sandstone and blue shale to creek,	15′

This shaly sandstone is the base of the *Chemung flags;* for, the top of the *Girard shale* is just sinking beneath creek level at this point.

In the 6″ layer of fossiliferous shale, may be seen multitudes of a shell very much resembling *Avicula fragilis.*

This is the lowest horizon at which I have ever found any fossils in the Chemung flags, and as we go down the stream from this point *not a trace of a fossil animal is seen in the fine exposures of the Girard shale.*

About one mile north from this (by the stream) the creek makes an oxbow a mile and a half round, and cuts down through the *Girard shale* between perpendicular cliffs 100′ high and sometimes more. The narrow tongue of land en-

closed within this rocky wall has been locally named the *Devil's back-bone.*

As we pass down Elk creek, the *Girard shale* continues to floor the stream and form cliffs along its banks until we reach Girard. Here the *Portage flags* begin to come up in the bed of the creek, and the layers of sandstone have there been quarried for a long time on the land of Dr. Ealy.

A short distance below where the road crosses Elk creek at Girard, and on the right bluff of the stream is seen section: (Fig. 87.)

Girard Section.

Girard shales, bluish-gray, ... 40′
Sandstone layer in bed of creek, ... 8″ to 10″

The shales belong to the lowest part of the 200′ of *Girard shale;* and this lower portion is somewhat silicious; but no layers of genuine sandstone are found in it until we come down to its base.

Ealy quarry.—The sandstone layer at the bottom of the section is the top of the *Portage* series of thin sandstones alternating with shales, which border the lake shore all the way to the N. Y. State line. Where quarried here on the land of Dr. Ealy it is a hard, blue, fine-grained sandstone, not quite one foot thick, and covered with *Fucoidal* markings; elevation 62′ A. L. E =635′ A. T.

Godfrey quarry.—As we descend the stream other layers of the *Portage flags* rise above water level and some of them are quarried on the land of Mrs. Godfrey, one mile below the Girard bridge.

Rice oil boring.—Near Girard, a well was drilled for oil in 1865 on the land of Dan. Rice. It commenced 25′ above creek level: (Fig. 88.)

Rice well record.

Conductor, (*Drift*), ... 20′
Blue shale with thin shells, soapstone, &c., to bottom, ... 980′

Very little gas and no oil were found in the well. The shales, &c., are reported as being very uniform in composition and color throughout.

Barometric elevations in Girard.

Forks at J. Miles' near mouth of Elk creek,	(above tide),	600′
" just south near shop,	"	670′
" east from J. Miles',	"	700′
" near crossing of Lake Shore R. R.,	"	715′
Cross roads in Girard,	"	770′
Forks of road just across the creek at Girard,	"	665′
" near R. Richter's,	"	710′
Level of stream next south,	"	710′
Forks near J. M. Laughlin's,	"	720′
" J. W. Blair's,	"	860′
" L. Foster's,	"	1000′
" M. B. Babbit's,	"	985′
Level of Elk creek opposite (south branch),	"	815′

44. *Fairview, in Erie County.*

This township, narrow on the Lake Shore, stretches south across Elk creek to Franklin township, between Girard on the west and McKean on the east.

A watershed passes nearly east and west across the township south from its central line, and the drainage south of this goes westward by way of Elk creek into Lake Erie, through Girard township; while north from the divide the water flows directly into the lake by means of Walnut creek and several small streams. The general elevation of this watershed is about 950′ A. T.

Leopold quarry.—The *Third Oil Sand* just caps the hills along the south line, and has been quarried to some extent on the land of Mr. Leopold. Here the quarry rock is 6′ thick and smells strongly of *petroleum*, as usual; while the oil itself floats off on the water from the base of the quarry. The stone has the usual bluish-gray cast so common to it in Erie county.

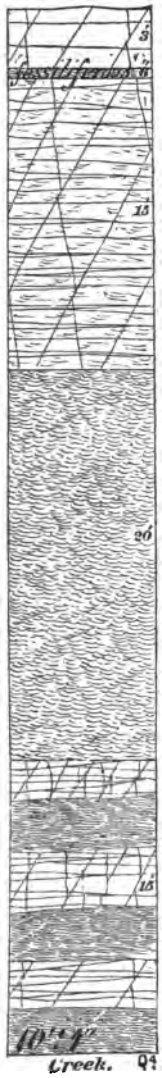
Descending a run which comes down over the outcrop of the *3rd Oil Sand*, and enters Elk creek near Mr. J. Ryan's, is seen the following section (Fig. 89):

Ryan's Section.

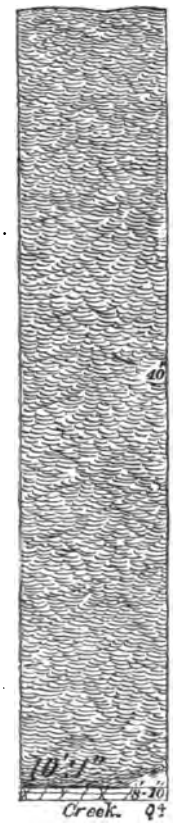
Third oil sand (quarry portion),	6′
Shales, sandstone and shales *to bottom limit of fossiliferous layers*,	270′ *

* The thickness, 270′, is calculated upon a south dip of 20′ for one mile, 20′ being added to a barometric height of 250′.

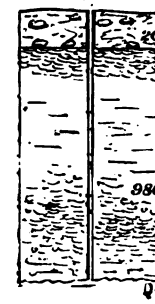
86.


3'
15'
20'
15'
10';1"
Creek.
Q⁴

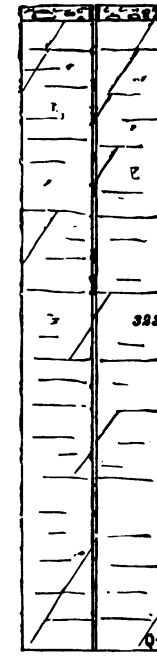
87.


40'
10';1"
18-20
Creek.
Q⁴

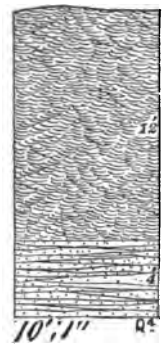
88.


20'
980'
Q⁴

85.


2'
2'
325'
Q⁴

84.


12'
4'
10';1"
Q⁴

Shaly and flaggy sandstone,	55′
Calcareous band,	0′ 6″
Girard shales, blue, to level of Elk creek,	50′

At this geological horizon (base of 270′) (*all fossil shells disappear;* the underlying succeeding 55′ of shales and flaggy sandstone are entirely destitute of any remains except Fucoids. The fossils closing this series seem to be very closely allied to, if not identical with *Avicula fragilis*, seen at the same horizon elsewhere in Franklin, Conneaut, and Girard townships.

The calcareous band in the section corresponds to one seen at the base of the *Chemung flags* in the section descending from Howard's quarry, in Franklin township.

Just below it (this calcareous band) there takes place a complete change of rock; not a single sandy layer being seen below it; but only very argillaceous, soft, ashen-gray shales, in which nothing but *fucoids* are visible; but these *fucoids* are in great abundance.

Luther's oil boring.—About one mile below this and near the mouth of Falls run, a well was once bored for oil on the land of Geo. P. Luther, to a depth of 1000′.

It was commenced at 785′ A. T.

A big gas vein was struck at 500′.

The *Girard shale* is finely exposed in frequent cliffs along Elk creek. On the main stream it continues above water-level, into McKean township. On the side streams it soon passes below drainage level. On the branch which puts in past R. Struker's, its top is seen at water level at 890′.

In this township the covering of *Drift* is not so deep along the lake shore; so that cliffs of the *Portage flags* are often exposed, especially near the mouths of streams and in their beds.

At the mouth of Trout run, 10′ of sandy shale is seen above lake level; and about 2′ under water is a bed of sandstone one foot thick, large blocks of which are frequently thrown up by the waves, and used for building stone. Sometimes when the lake level is low the bed itself is actually quarried. The rock is quite hard, of a bluish-gray color, and its surface is covered with *fucoids*.

Woolen factory bore-hole.—Just at the mouth of Trout run a hole was once bored for oil on the property of the old woolen factory, commencing 10′ above Lake Erie; it was drilled to a depth of 700′, and according to the reports of one of the drillers, passed through "blue soapstone with an occasional thin shell" all the way down, except that, near the bottom, streaks of dark slate were sometimes found 2″ to 3″ thick.

At 350′ a great *gas vein* was struck which furnished more than enough fuel to run the woolen factory before the latter was burned down. The gas still bubbles from the hole, although it is filled up with water and rubbish.

About two miles further northeast along the lake we come to the mouth of Walnut creek, a large stream which drains the eastern portion of the township, bounded by rocky walls its entire course (in Fairview) offering to view fine exposures of the strata.

At the mouth of Bear's run, Walnut creek cuts down to the top of the *Portage flags;* and from this to its mouth descends over a succession of thin sandstone layers, separated by blue shales.

Quarries.—Near the mouth of Walnut creek and 10′ above the level of the lake, two layers of sandstone have been quarried; the upper layer is 1′ thick; separated by 3′ of shale from the lower layer, which is only 6″ thick; both are quite hard, bluish-gray, fine-grained and covered with *fucoids*, mostly cylindrical.

Reed's gas well.—At the mouth of Walnut creek an oil well was once sunk to a depth of 750′ on the land of Mr. Reed. Gas was obtained at 250′ and 400,′ but no oil at any depth.

Just below where the road crosses Walnut creek first above its mouth, a layer of sandstone 1′ thick is seen in the bed of the stream, 12′ above the lake level (585′ A. T.); most probably the stratum thrown up by the waves at the mouth of Trout run, 2 miles to the westward; and the two rocks resemble each other.

Davidson's quarries.—About one fourth of a mile up Walnut creek from where the road crosses it, we come to

the quarries of Mr. Davidson, where a large amount of rock has been taken from the bed of the stream. The sandstone is about 5′ thick, in several layers 2″, 4″ and 8″ thick, and sometimes the layers run together making 18″ to 2′ of solid stone.

Oil plant bed.—An abundance of vegetable fragments are here seen in the rock, and it smells strongly of *petroleum.* Mr. Davidson states that oil frequently floats out on the water from the bottom courses of rock when they are lifted. The fragments of vegetable matter are too much carbonized for identification, but some of them were evidently branches from trees of considerable size. Some of them are covered with thin films of coaly matter.

As we ascend Walnut creek, the last of these flaggy sandstone layers passes below water-level at about 700′ A. T. (127′ above the Lake) and then we see vertical cliffs of the *Girard shale* 50′ to 60′ high hemming in the narrow valley of the stream. This shale continues to border the creek as we ascend it until we enter Mill creek township.

Barometric elevations in Fairview.

Level of Elk creek at road crossing near S. Luther's,	(above tide),	810′
Forks of road next east,	"	840′
" near C. Leopold's,	"	940′
" " F. Leopold's,	"	950′
" " C. L. Galusha's,	"	990′
" east at township line,	"	975′
Level of Elk creek north from C. Smalley's,	"	850′
Cross roads near J. Guerflo's,	"	955′
" " G. Shoemaker's,	"	935′
" " G. P. Luther's,	"	935′
Forks at J. Ross's,	"	900′
Level of Brandy run near M. W. Wheeler's,	"	880′
Cross roads north at School House,	"	895′
Forks near T. Sturgeon's,	"	770′
Cross roads in Fairview village,	"	780′
Crossing of old canal next north,	"	725′
Cross roads near J. Shuster's,	"	675′
Lane near J. Mellhorg's,	"	695′
Cross roads near W. Wentz's,	"	705′
Level of Walnut creek near T. McKee's,	"	610′
Forks east at School House,	"	705′
" near B. Swan's,	"	725′
" " J. Evan's,	"	765′
" in Swanville,	"	785′

Level of Walnut creek, near J. Gudtner's, . . .	"	700′
Forks west from W. Nicholson's, ...	"	815′
" near M. Barnett's, ...	"	875′
" " C. Heidler's, ...	"	900′
Cross roads near G. J. Snider's, ...	"	945′
Forks near S. Cushman's, ...	"	945′
" " V. Heintz's, ...	"	900′

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45. *McKean, in Erie county.*

This central township of the county is a basin surrounded by a continuous water-shed, broken through at the west, where the waters of Elk creek find an exit.

Elk creek takes its rise on the eastern border, at the low water-shed between it and the head of Le Bœuf creek.

The rock series in this township extends up to the top of the *Venango oil group* in the southern portion, where the surface rises to 1500′ above tide; and Elk creek, before it passes into Fairview, cuts down to the *Girard shale;* so that the *Chemung flags* form the surface rocks over all except the southern and eastern portions of the township.

Lamson's run (heading in the extreme southern part, and flowing northward into Elk creek at Middleboro') cuts down to the *Third oil sand* about one half mile north from the township line.

Lamson's quarry.—Here the sandstone in the bed of the run has been quarried for a long time past. The bluish-gray or quarry portion is 5′ thick; in about four layers. The rock has the same physical aspect as at Howard's quarry, four miles west; *smells strongly of oil;* and there are petroleum springs all around its base. A great many *fucoids* are seen with the quarry rock.

It dips visibly northward here, but this is a local irregularity; for, two miles further north the regular south dip is seen.

Base of *Third oil sand* at Lamson's quarry 1160′ A. T.

About one mile east from Middleboro', along a small stream which puts into Elk creek near that village, the following section is seen including the *Third oil sand*: (Fig. 90, a repetition of Fig. 18, in Part I of this report.)

Middleboro' Section.

1. Blue shale,		visible, 5′
2. Rough Fucoidal sandstone,	6′	
3. Shales and flaggy sandstone,	12′	*Third oil sand*, 25′
4. Quarry rock,	7′	
5. Shales,		?

No. 2 is the same iron-stained rough siliceous rock that we so often see 8′ to 12′ above the *quarry portion* of the *3rd oil sand;* it is filled with Fucoids of almost every shape; some are long and cylindrical, lying horizontal in the rock; many are vertical; while others have a horse-shoe shape. It is the effect produced by their more rapid weathering which renders the upper surface of this stratum so rough and irregular, being covered with prominences, and filled with holes.

No. 4, the quarry portion of the *3rd oil sand*, has the same physical aspect that it exhibits everywhere in the county, and is perfectly *saturated with petroleum*, pools covered with oil being seen all around its base, which comes here at 1200′ above tide.

As we go east from this the surface rises to 160′ above the level of the *3rd oil sand* at the cross-roads near Mr. E. Bates's.

Vorse quarry.—About one mile west from Middleboro', a bed of sandstone has been quarried from the bed of Elk creek on the land of Mr. Vorse; the stratum is 1′ to 1½′ thick and comes very near the base of the *Chemung flags*, since at the mill two miles below, the *Girard shale* appears in the bed of the creek just before it leaves the township.

Veight's quarry.—North from Elk creek everything is covered beneath *Drift* and no rock exposures are seen except near the eastern line, where the *3rd oil sand* has been quarried in the edge of McKean on the land ofMr. Veight.

Near the northern line at Rohrer's Tannery, a wide level reach of country is seen stretching away toward Lake Erie at a height of 1070′ A. T. This may possibly represent one of the terrace levels left by the retreating waters of Lake Erie when it stood at a much higher level than now.

Barometric elevations in McKean.

Cross roads in Middleboro',	(above tide),	1070′
Level of Lamson's run just west,	"	1010′
Forks near A. M. Vorse's,	"	1020′
" V. Sallinger's,	"	1020′
Level of Elk creek just north,	"	990′
Cross roads near J. A. Sterrett's,	"	1030′
Forks next northeast,	"	1100′
Forks near J. Bowman's,	"	1115′
" S. Rohrer's,	"	1070′
Cross roads near W. Slack's,	"	1080′
Forks near L. Olenbauher's at western line of township,	"	965′
" J. Wheeler's,	"	980′
" C. B. Wright's,	"	1000′
Forks next east,	"	1030′
Cross roads near D. Harrison's,	"	1090′
Forks next east,	"	1130′
" near D. Hayford's,	"	1055′
" next south,	"	1050′
Cross roads near E. Lamson's,	"	1165′
" west from R. F. Sterrett's,	"	1325′
" near school house No. 4,	"	1400′
Forks near J. Comer's,	"	1500′
" next east at township line,	"	1500′
Level of Elk creek near L. Grant's,	"	1230′
Cross roads near J. Aubrey's,	"	1260′
" " E. Bates',	"	1365′
Level of Elk creek near O. Dun's,	"	1085′
Cross roads near E. Piney's,	"	1110′
Forks near W. Maynard's,	"	1080′
Level of Elk creek near L. Glazier's,	"	1060′

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46. *Waterford, in Erie county.*

This township lies on each side of Le Bœuf creek which flows through it from north to south. Trout or Black run drains its western side into Le Bœuf lake. The north branch of French creek cuts across its southeast corner.

There is scarcely any "divide" between the head waters of Trout run and the head waters of Elk creek, both heading in *Tamarack swamp*.

Hills and hummocks of *glacial gravel* are seen everywhere.

The rocks of this township belong to the *Venango oil*

group, and the *Chemung flags*. None of the streams cut through this last formation into the *Girard shale*.

The *Third oil sand* is exposed at many localities and has long been quarried extensively as a building stone.

The Middleton quarry is just at the southeastern corner of the township. Here on the land of J. W. Middleton, at the roadside, along a small stream which puts into the North branch of French creek, is seen the following section: (Fig. 91.)

Middleton quarry section.

Blue shale,		2
Pebble rock,	1′	3rd oil sand, 6′
Fucoidal layer,	0′ 1″	
Quarry rock,	5′	

This is the first place coming east where I *found any pebbles* in connection with the *3d oil sand*, since leaving it at Le Boeuf or Carroll's quarry. The distance is about 2½ miles.

The top layer is a perfect *mass of flat quartz pebbles*, and is quite irregular in its thickness, since on the opposite side of the road, only 3 rods away, I saw it 3′ thick and not all of it exposed.

A hard shell of sand, immediately under the pebble bed, is a perfect *mass of fucoidal remains*, many of which very much resemble *F. graphica Hall.*

The bottom rock is rather flaggy at this quarry, the layers being only 4″ to 6″ thick, but in other respects have the typical character.

McClelland quarry.—On the opposite side of the run a quarry is now operated on the land of Mr. McClelland by Mr. Young. Here we see 2′ to 3′ of the *pebble rock* and the top is then concealed.

Under the pebbly layer comes 3′ to 4′ of very good *building stone*, and Mr. Young ships a considerable quanity of it to Erie, Corry, and other places principally for doors and windows, as well as stepping stones. The rock is bluish-gray and slightly harder than the same stratum in Le Boeuf, but very closely resembling it in every other respect. The

stone smells strongly of *petroleum;* and Mr. Young states that he often finds small pools of it under the bottom courses of the quarry and in the crevices between the joints. He also told me that in quarrying he often found pieces of what seemed to him like "*old rotten wood.*" These were most probably fragment of branches that had been partially converted into petroleum, the same as those seen at Kanty quarry in Le Boeuf.—Base of bottom rock 1275′ A. T.

Skabel's quarry.—Just north of this the flags have been quarried by Mr. Skabel.

The Old Middleton quarry, in the *Third oil sand* is about one mile west from this and on the opposite side of French creek, in the *Third oil sand.* Many years ago it was worked to a considerable extent, but is now entirely abandoned. The rock in it contains *much oil*, as can yet be seen in buildings constructed from it. The Eagle hotel in Waterford was built of this stone more than 50 years ago, and yet the smell of *petroleum* still prevades it. Many of the blocks of stone were so saturated with oil that it has run down the sides of the building and blackened several courses.

In descending the hill east from Waterford to the track of the Philadelphia and Erie R. R. below the station, the outcrop of the *Third oil sand* is seen at 1280′ A. T.

The rock is here a flaggy sandstone and *not a pebble is to be seen* in connection with it, but the same association of fossils identifies the rock, especially *Rhynchonella contracta* which is here seen in great abundance.

Oil boring.—Two miles west from Waterford borough an oil well was once sunk to a depth of 650′. Some gas and a slight show of oil was obtained. The well commences at 1260′ A. T., but unfortunately like so many other wells in Erie county begins *below* the horizon of the *3rd oil sand*, since the base of that rock is seen in the bank 10′ above the mouth of the well. Only about 3′ of the *3rd oil sand* are seen here, since the upper portion is covered under débris; the lower portion however has the usual character of the quarry rock, and contains great numbers of *Rhynchonella contracta.* The elevation (1270′ A. T.) is also confirmatory

evidence of its identity, since this is exactly what we should expect from the known dip of the strata.

Shallow boring.—In the valley below this an attempt was once made to drill another well, but when the drive-pipe had passed through 50′ of *Drift* it struck a bowlder and the advance end was broken up before it was known what was the matter, so that the hole was abandoned.

Trending a little west of north from Waterford is a very broad high ridge, extending up 150′ above the *3rd oil sand* or to about 1450′ A. T.; covered with *Drift* and no outcropping rocks seen anywhere upon it.

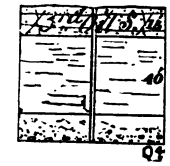
The valley of Le Bœuf is very wide, and great heaps of *Drift* material are seen in many places along it, and especially where it has been cut through by the streams.

Barometric elevations in Waterford.

Level of Eagle Hotel, Waterford, ...	(above tide),	1185′
Forks of road north from Waterford, where road turns off to Trout run, ...	"	1240′
Forks near Mrs. S. Phelps', ...	"	1220′
Cross-roads near Mattson's School House, . . .	"	1255′
Forks near S. Harbison's, ...	"	1310′
Cross-roads near W. Sharp's, ...	"	1465′
Forks near C. Comer's, ...	"	1390′
Forks north near School House, ...	"	1410′
Cross-roads near L. Williams', ...	"	1385′
Forks next west, ...	"	1465′
Cross-roads south from Williams', ...	"	1385′
Forks near C. J. Chase's, ...	"	1280′
Level of LeBœuf creek below Waterford Station,	"	1175′
Forks near G. W. Cooper's, ...	"	1465′
Cross-roads near G. Billings', ...	"	1345′
Forks near W. King's, ...	"	1355′
" " Dr. Faulkner's, ...	"	1255′
Level of French creek opposite, ...	"	1225′
Forks east from this, ...	"	1255′
" near J. M. Middleton's, ...	"	1260′
" " J. Canning's, ...	"	1335′
" " W. B. Lloyd's, ...	"	1280′
" " J. P. Vincent's, ...	"	1290′
Cross-roads near W. Knox's, ...	"	1410′
Forks near J. Haynes', ...	"	1470′
" " A. C. James', ...	"	1460′
" " J. Sherwood's, ...	"	1450′
" " F. D. Strong's, ...	"	1470′

Doolittle's bore hole.

93.



...*and*, (quarry rock,)	15′
...e,"	40′
...n pebbles, show of oil at 70′, ...	—
...r, yellow, like honey."	
...gas veins at many points in the well."	
...ified to depth of 630′."	

...tom of the quarry rock at Doolittle's has an ele-...barometer of 1320′ A. T. This determination was ...fully checked so that it cannot be more than 5′ in

...-In descending the hill road one half mile ...Doolittle's a bed of red shale, of which 5′ are ...curs, at 1460′ A. T., or 120′ above the top of the ...*and*, (or adding 10′ for southward dip of the lat-...) making it most probably the *red bed* found so ...nnection with the *Second oil sand.*

...*quarry.*—Passing down Doolittle's run two miles ...thwest, we come to another quarry in the *Third* ...on the land of Mr. Allen. Here along a ravine at ...y is seen section Fig. 94.

Allen's quarry Section.

...nty sandstone, ...	*Third Oil Sand,*	. . 2′
...le, ...		. . 2′
...*ble rock,*		. . 2′ 6″
...ggy sandstone, ...		. . 5′
...ue shale, ...		. . 7′
...ndstone, quarry rock, .		. . 1′
...ue shale, ...		. . 0′ 6″
...ndstone quarry rock, .		. . 1′
...ue shales seen, ...		. . 5′

1 to 8 represent the *3rd oil sand*, and the quarry por-...here reduced to the two layers of sandstone near the ..., since that immediately below the pebbly layer is ...ly.

... corresponds to No. 1 in the section at Doolittle's, ...very much like it in every way, being if possible more ...s, in fact almost chert.

... is a perfect mass of flat quartz pebbles held together ...arse mud-colored matrix. It is saturated with pe-...m.

Venango Oil Group down into the *Chemung flags;* since French creek cuts down below the horizon of the *Third Oil Sand* throughout its entire course in this township; and the highlands near the southern portion of the same extend up 300′ above the *Third Sand.*

The *Third Oil Sand* is exposed at many places in this district, and has been quarried in several localities, the most important of which is probably the *Doolittle quarry*, on a tributary of French creek, one and a half miles north from the southern line. It shows the following structure (Fig. 92):

Doolittle quarry section.

Hard, siliceous, *fossiliferous* sandstone,	2′
Pebbly layer,	8′
Bluish-white sandstone,	reported 15′

The top sandstone is very fossiliferous, being covered at top with a *fucoid* very much resembling *F. cauda-galli*, and in it are also seen multitudes of *Rhynchonella contracta*, *Streptorhynchus chemungensis*, *Grammysia hannibalensis*, and many other forms; indeed so abundant are the shells that this layer often becomes a kind of limestone.

The pebble rock is a mere mass of flat pebbles of white, green, dark, and mottled quartz in a matrix of very coarse greenish sand; a large piece of feldspar was also seen in one of the pebbly portions.

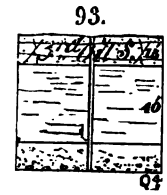
The bottom or quarry rock, has been worked to a considerable extent and very much resembles that at Le Boeuf. Only 5′ of the rock are seen, but Mr. Doolittle told me he had drilled down through it, and found its real thickness to be 15′. The stone smells of *petroleum* as usual.

As we ascend the small run towards the northeast, the *Third oil sand* rises about as fast as the bed of the stream, or nearly 40 to the mile.

The indications of oil in connection with the quarry rock led Mr. Doolittle to sink an oil well, and he reported the following succession: (Fig. 93.)

Doolittle's bore hole.

1. *Third oil sand,* (quarry rock,) . . . . . 15′
2. "Soapstone," . . . . . 40′
3. Sand with pebbles, show of oil at 70′, ... —
   "Oil, clear, yellow, like honey."
   "Heavy gas veins at many points in the well."
   "Drilled to depth of 630′."



The bottom of the quarry rock at Doolittle's has an elevation by Barometer of 1320′ A. T. This determination was twice carefully checked so that it cannot be more than 5′ in error.

Red shale.—In descending the hill road one half mile south from Doolittle's a bed of red shale, of which 5′ are exposed, occurs, at 1460′ A. T., or 120′ above the top of the *Third oil sand*, (or adding 10′ for southward dip of the latter rock 130′) making it most probably the *red bed* found so often in connection with the *Second oil sand.*

Allen's quarry.—Passing down Doolittle's run two miles to the northwest, we come to another quarry in the *Third oil sand* on the land of Mr. Allen. Here along a ravine at the quarry is seen section Fig. 94.

Allen's quarry Section.

1. Flinty sandstone, ...	*Third Oil Sand,*	. . 2′
2. Shale, ...		. . 2′
3. *Pebble rock,*		. . 2′ 6″
4. Flaggy sandstone, ...		. . 5′
5. Blue shale, ...		. . 7′
6. Sandstone, quarry rock, .		. . 1′
7. Blue shale, ...		. . 0′ 6″
8. Sandstone quarry rock, .		. . 1′
7. Blue shales seen, ...		. . 5′

Nos. 1 to 8 represent the *3rd oil sand*, and the quarry portion is here reduced to the two layers of sandstone near the bottom, since that immediately below the pebbly layer is too shelly.

No. 1 corresponds to No. 1 in the section at Doolittle's, and is very much like it in every way, being if possible more siliceous, in fact almost chert.

No. 2 is a perfect mass of flat quartz pebbles held together by a coarse mud-colored matrix. It is saturated with petroleum.

Nos. 6 and 8 are the only courses quarried here, they having been mined along the little ravine by stripping off the shales above.; both are of a bluish-white color, rather hard but excellent building material since the weather has scarcely any effect upon it. The bottom of this No. 8 comes at 1355′ above tide, being 35′ higher than the base of the same stratum at Doolittle's, 2 miles to the southeast.

Second Oil Sand?—As we pass south from this toward Union, the outcrop of a yellowish sandstone is seen at 1490′ A. T., which very probably represents the *Second oil sand horizon;* and on going further south we see a grayish-white flaggy sandstone near the southern line of the township at an elevation of 1560′ A. T. This would come near the horizon of the *First oil sand*, since the southward dip would place it about 275′ above the *Third oil sand.*

About two miles north from Allen's near the northern line of the township we see the outcrop of a bluish-white sandstone on the land of Mr. Finley at an elevation of 1400′ A. T., thus being most probably the representative of the *Third oil sand.*

About ¾ mile south from where the North Branch of French creek enters the township a splendid exposure of the *Third oil sand* occurs on a small stream which flows north into French creek. The rock is there 20′ thick on the land of Mr. J. R. Smith, and consists entirely of pebbly layers, the quarry portion usually found below the *conglomerate* being reduced to nothing by the incursion of the coarse material.

This *mass of flat pebbles* is *saturated with petroleum*, and the oil floats off on the water from its base. The little stream passes over the entire outcrop of the rock in a series of cascades, thus exposing it very finely. It also forms a cliff around the hill, and many large blocks of the rock are scattered over the field.

The base of the stratum has an elevation of 1375′ A. T., or 55′ higher than the same part of the rock at Doolittle's quarry, 2½ miles south, thus showing a rise of 22 feet per mile in a direction about North 10° East.

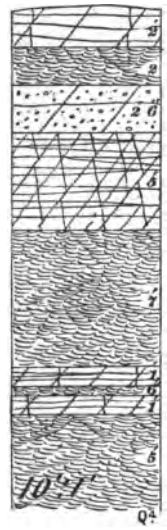
The section seen here is as follows (Fig. 95. See Fig. 15, p. 109.):

J. R. Smith Section.

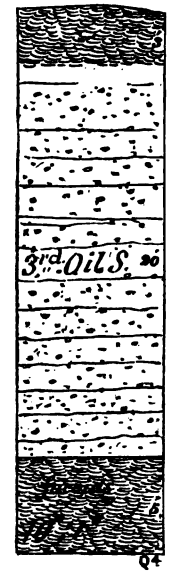
Shales,	visible 3′
Third Oil Sand, mass of pebbles, in layers 1′ to 4′ thick,	20′
Blue shales, with *Fucoids*,	5′

It is an instructive lesson in showing the great changes constantly taking place in the structure of this and other sandy deposits, to compare the section here with that at Doolittle's and Allen's, given on preceding pages.

94.



96.



Maynard's run rises at the eastern edge of the township, and flows northwest into French creek near where the latter stream enters the township. Along this stream the *Third Oil Sand* is exposed in many places; the first locality near the head of the run is on the land of Mr. Hubbell, and here the following section is seen (Fig. 97):

Hubbell's Section.

Flaggy Sandstone (*Second Oil Sand?*),	10′
Concealed,	100′
Bluish-white sandstone (*Third Oil Sand*),	10′
Concealed to level of run,	20′

The top rock of this section forms a steep bluff around the top of the gorge.

The *Third Oil Sand* has been quarried in the bank of the stream, and it is of a lighter color than usual, being almost white in some of its layers; the pebbly portion is concealed at this locality, or else absent altogether, as nothing was seen of it. Beneath the base of the exposure a line of *oil springs* come out around the bluff.

About one half mile northwest from Hubbell's the *Third Oil Sand* becomes very massive and is seen on the land of Mr. Maynard forming *a cliff of conglomerate* along the hill above the road (which passes down Maynard's run) and immense blocks, some as large as an ordinary house, lie scattered over the field below. These blocks are mere agglomerations of *quartz pebbles*, of almost every shade of color, white, red, green, dark, &c.; many of them are 1½ inches long, and all are much longer than thick. This flattening seems to have been universal in the pebbles of the *Third Oil Sand*. All give evidence of long attrition in water.

Along a ravine which comes in just north from Maynard's house the following exposure is seen (Fig. 98):

Maynard's Section.

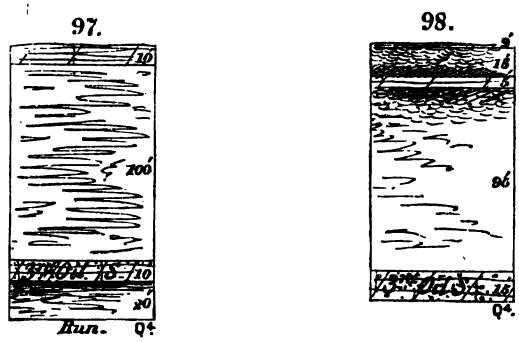
Sandstone (*Second Oil Sand?*), ...	visible 2′
Shales, ...	15
Buff sandstone, rather massive, ...	5′
Shales and concealed, ...	95′
Pebbly sandstone (*Third Oil Sand*), ...	15′

About midway of the 95′ shales occurs a rather sandy portion, very hard, and 5′ thick.

The *Third Oil Sand* is pebbly throughout, and quite massive; it possesses a strong odor of *petroleum*, and *pools of oil* are seen in the stagnant water at its base, which has an elevation of 1380′ above tide.

Maynard Quarry.—A short distance north from this, Mr. Maynard has a quarry in the *Third Oil Sand*, though it is so pebbly that no first-class stone can be obtained from it, as the pebbles occur in streaks all through the stratum. An *oil spring* comes out of the rock at this locality, from which petroleum is often collected for lubricating purposes.

Lowe's quarry one mile N. E. from Maynard's the *Third Oil Sand* is finely exposed along a stream which puts into Maynard's run from the east. It has there been quarried on the land of Mr. U. B. Lowe, where we see the following (Fig. 99):



Lowe's section.

Shales,		5′
Pebble rock,	5′	*Third oil sand*, 15′
Bluish white sandstone,	10′	
Shales,		visible 3′

The pebbly rock is quite variable in thickness being only 1′ thick at the head of the falls where the stream pours over it, but further down the stream thickening up to 8 feet.

A large amount of building stone has been quarried in the past from the white sandstone, but as the quarry is in the woods it has lately been abandoned and the road to it is blocked up with fallen timber. The rock is grayish-white with a tinge of blue, and is also *saturated with oil*, which covers the surface of pools around the outcrops of the stratum.

Oil boring.—These "oil shows" induced a company to sink a well to a depth of 500′ to 600′, commencing just below the quarry; of course nothing of value was obtained except some rather strong *gas veins.*

Barometric elevations in Amity.

Forks near center line of south boundary,	(above tide),	1595′
Forks at S. Bemas',	"	1520′
Forks near W. Hatch's,	"	1325′

Forks near S. Doolittle's,	(above tide),	1320′
" J. Chaffee's,	"	1335′
" C. Colburn's,	"	1425′
" N. Chaffee's,	"	1445′
Cross roads near J. W. Stone's,	"	1320′
Forks next southwest,	"	1335′
" "	"	1395′
Level of French creek opposite J. W. Stowe's,	"	1310′
Forks near L. A. Stowe's,	"	1325′
" W. A. Donaldson's,	"	1345′
Cross road near W. Parker's,	"	1285′
Forks near G. Davis',	"	1330′
" S. Brown's,	"	1290′
" D. Finley's,	"	1325′
" W. William's,	"	1350′
" school house No. 4,	"	1320′
" G. Sammon's,	"	1315′
" school house No. 9,	"	1375′
" C. Maynard's,	"	1495′
Cross roads near H. Person's,	"	1470′
Forks at school house No. 2,	"	1520
Cross roads near E. B. Wheeler's,	"	1510′

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48. *Wayne, in Erie county*

This township corners on New York State and Warren county.

Its western half drains south into French creek by Beaver run, Slaughter's run, Baskin's run, and Spencer's run.

Its eastern half drains southeast by Hart run and Bear creek.

The Brokenstraw flows southeast across the extreme northeast corner.

Both the Brokenstraw and Hare's creek flow in old *Drift* filled valleys.

In the case of Hare's creek the "divide" which reaches an elevation of nearly 1800′ along the northern line of the township, has been cut through so that where the water turns northward in it the elevation is only 1500′ A. T. and the slope is so imperceptible that it is very difficult to locate the line of the water-shed, while the bounding valley walls rise 250′ above the same. The water flowing north in this old valley passes into a fork of North French creek in the State of New York.

The rocks of this township belong exclusively to the *Venango oil group*, with possibly one or two exceptions where high knobs rise above the *First oil sand.* The surface is so deeply buried with drift however, that exposures of any kind are very rare.

Russell's quarry.—Near the eastern line of the township on a small stream which empties into Francis' run, a grayish-white sandstone occurs, which has been quarried by Mr. Russell. It is about 5′ thick and is rather hard; contains much *petroleum* in the crevices and porous portions of the stone. It has an elevation of 1600′ A. T., and represents one of the *sands* in the *Venango oil group.*

Oil boring.—A short distance north from this, a well was bored for oil on the land of Mr. Henry, to a depth of 600′, but no oil of any consequence was obtained, though some very strong gas strikes were made.

Along the Big Brokenstraw valley the hills rise quite abruptly on its right bank, though the slopes are so covered with Drift that no exposures are to be seen. In some places, however, blocks of a conglomerate rock very much resembling the *Third Oil Sand* are scattered over the ground, and there is no doubt that this stratum crops out under the *Drift* along the hillside above the valley.

Quarry.—Just across the New York State line, and one fourth of a mile west from the Big Brokenstraw, the *Third Oil Sand* has been quarried in a ravine; the stratum quarried is 4′ to 5′ thick, and is the base of the rock, being a bluish-white, tolerably fine-grained stone, having the odor of *petroleum;* its base occurs at 1500′ above tide, and this is exactly where it should be when carried here in the dip from LeBœuf at the southwest, or Wattsburg at the west, and then the physical appearance of the rock itself is sufficient evidence of its identity, even if it were not supplemented by the evidence of fossils; but when we find in it *Rhynchonella contracta*, the evidence is complete and perfectly satisfactory, so that there is no doubt whatever that this stratum represents the LeBœuf quarry rock.

About 4½ miles northeast from this there is an extensive quarry in the *3rd Oil Sand*, in the State of New York, and

the rock has there the same characteristics that it has everywhere in Erie. Then going 4 miles further to the northeast we come to the famous ledge of *Conglomerate at Panama*, where the base of the stratum is 1600′ A. T., or 100′ higher than at the State line on the Brokenstraw, which is also about what the average rise of the rocks in that direction should make it; so there can be no doubt that the *LeBœuf Conglomerate* is the same stratum as the *Panama Conglomerate*, and that both are equivalents of the *Third Oil Sand of Venango.*

In the neighborhood of Carter Hill P. O. the surface rises to 1800′ above tide, and extends up a short distance above the *Venango Oil Group*, but nowhere in the township is the *Corry Sandstone* caught in the hills.

Barometric elevations in Wayne.

Forks of road near C. I. Webber's, north from Corry,	(above tide),	1410′
Forks near H. D. Francis',	"	1420′
" W. W. Henry's,	"	1600′
" J. Brewer's,	"	1450′
" H. Johnson's,	"	1490′
" C. Williams',	"	1510′
" B. C. Bemis',	"	1560′
" C. E. Avery's,	"	1420′
" Mrs. Graves',	"	1640′
" N. B. Creeley's,	"	1720′
Fork just west from Hare's creek, at N. Y. line,	"	1500′
Fork near A. Raynold's,	"	1475′
Cross-roads near H. S. Pitt's,	"	1800′
Carter Hill P. O.,	"	1790′
Forks near A. J. Ford's,	"	1700′
" C. A. Perkins',	"	1635′
" P. Miller's,	"	1480′
" J. Coon's,	"	1525′
Level of Stoughter's run, near J. Lyons',	"	1410′
Cross-road in Beaver Dam,	"	1435′
Forks near W. F. Follett's,	"	1455′
" W. Smith's,	"	1480′
Cross-roads near J. Allen's,	"	1510′

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49. *Venango, in Erie county.*

This township lies immediately north from Amity along

the New York line, and French creek north branch flows across it southward; Safford run coming in from New York at its southeast corner. Six Mile creek heads at its northwest corner and flows northward into Lake Erie.

The rocks of the township belong to the *Oil sand group* and to the *Chemung flags* below. At no locality does the surface rise more than 250′ above the *Third oil sand*, and the horizon of that rock is above water level along all the principal streams, but as everything is deeply buried with *Drift*, it is rarely seen.

Safford's run puts into North French creek just south from Wattsburg at the southern line of the township. The *Third oil sand* is constantly above its level and often seen until we come to Mr. D. P. Bailey's where it sinks below drainage level. At Mr. Bailey's it exhibits the following structure before passing out of sight: (Fig. 100.)

Bailey's section.

Pebble rock,	0′ 6″
Shales,	2′
Sandstone, bluish-gray; hard; *fucoids*,	0′ 6″
Shales; *fucoids*,	2′
Sandstone in bed of run; *fucoids*,	1′

This section presents a striking contrast to that obtained 2½ miles southwest from here on the land of Mr. Smith in Amity, where the pebble rock is 20′ thick, whereas here only 6″ is to be seen; its base at the level of the run here being 1425′ A. T., and at Smith's 1375′, there can be no doubt of its identity.

There may be more of the sandstone below water-level as the base of it was not observed; the lower sandstone layers are bluish-gray in color and tolerably hard. Many *fucoids* are seen in the intervening shales.

About 2 miles west from Wattsburg where the road crosses a small stream on the land of Mr. Baldwin many blocks of the *Third oil sand* are seen along the valley at a height of 1400′ A. T., and as there is a bluff at this horizon, the rock evidently has a considerable development.

Many portions of this township have been planed down below the general level.

Lake Pleasant lies surrounded by low hills of glacial *Drift*, half a mile long, a quarter of a mile wide; water level 1325′ A. T.

Barometric elevations in Venango.

Wattsburg,	(above tide),	1325′
Level of French creek there,	"	1315′
Forks near J. Moore's,	"	1375′
" H. G. Tracy's,	"	1380′
" H. Black's,	"	1400′
Cross roads near R. Week's,	"	1500′
" " H. E. Ladd's,	"	1700′
" " L. Chapin's,	"	1350′
Forks next north,	"	1400′
" near P. H. Yost's,	"	1600′
Cross roads near T. Henderson's,	"	1440′
" " J. H. Smith's,	"	1425′
" " T. M. Robinson's,	"	1360′
" " J. Smith's,	"	1515′
" " A. Beanas',	"	1540′
Forks near D. Peck's,	"	1530′
" H. Howland's,	"	1490′
Cross roads near E. K. Foster's,	"	1400′
Lake Pleasant,	"	1325′
Forks near Wm. Allison's,	"	1410′
Cross roads near T. Butler's,	"	1620′
Forks near J. Munsel's,	"	1600′
" J. Chapin's,	"	1360′
Cross road near Mrs. Carson's,	"	1360′

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50. *Greene, in Erie county.*

This township surrounds the head waters of Le Bœuf creek, east branch.

A low (1400′ A. T.) broad, flat divide ranges east and west across its northern half, draining southward into Le Bœuf creek, and northward into Crowley's run and Six mile creek. Walnut creek also heads along its northwest line.

The rocks of this area belong to the *Oil sand group* and to the underlying *Chemung flags;* the former occupying all the highlands; the latter exposed along the streams and in their bounding valley walls. The *Drift* however covers the rocks so completely that only a few exposures are seen.

About one half mile south from the northern line of the

township, near Mr. M. Netegan's the surface rises to 1400′ above tide, and there along the road is seen the rough *fucoidal sandstone* that so often occurs 10′ to 15′ below the quarry portion of the *Third oil sand*, so that this latter stratum just misses the surface.

Appleman's quarry.—One mile south from Netegan's a stratum of blue sandstone (*Chemung flags*) is quarried on the land of Mr. Appleman, 2½′ thick; in three layers; 1320′ above tide.

Ripley's quarry.—A short distance south from this the same stratum is quarried by Mr. Ripley in a gulch below the road, at 1310′ A. T.

Where the road crosses Crowley's run, south from this, a blue flaggy sandstone is seen in the bed of the stream, filled with Chemung shells; *Orthis unguiculus*, *Atrypa hystrix*, and many others.

In the southeastern portion of the township, the outcrop of a somewhat massive sandstone of a bluish-white color is seen on the land of Mr. Cutlar, just before we cross the headwaters of LeBœuf creek; base 1400′ A. T.

Barometric elevations in Greene.

Forks near A. Baker's (north line of township),	(above tide),	1305′
Cross-roads at C. Weber's,	"	1350′
Forks next south at School House,	"	1360′
Level of Crowley's run, near W. Urch's,	"	1230′
Forks at D. Ripley's,	"	1320′
Forks near Mrs. Bailey's,	"	1360′
Cross-roads near E. Ring's,	"	1370′
Forks near H. Seymour's,	"	1340′
" J. Entley's,	"	1300′
Level of LeBœuf creek, here,	"	1290′
Cross-roads near W. B. Weed's,	"	1420′
Forks next southeast,	"	1395′
Cross-roads at School House No. 3,	"	1390′
Forks near Mrs. Foster's,	"	1370′

51. *Summit, in Erie County.*

This township surrounds the headwaters of LeBœuf creek, west branch, flowing south, and of Walnut creek, flowing

north and then west into Lake Erie. Elk creek touches the southwest corner.

The divide makes almost a semi-circle within this area; entering it from the southeast, it separates Walnut creek and LeBœuf, and passing north around the head of this latter stream to the central portion of the township, it makes a short curve southward between Elk creek and LeBœuf. The height of the watershed varies from 1300′ to 1400′, being seldom more than 1350′ A. T.

The section of rocks includes the lower portion of the *Oil Sand Group* and the *Chemung flags*, since Walnut creek cuts far down into these before leaving the township.

The *Third Oil Sand* is to be seen at many localities, and has been quarried at several places for a long time.

Reynold's quarry.—One of these is on the land of Mr. Reynold, along a branch of LeBœuf creek, 1½ miles west from Jackson Station, on the Phila. and Erie R. R. Here the following succession is observed (Fig. 101):

Reynold's Section.

Fucoidal sandstone,	visible	2′
Blue shale,		8′
Quarry rock; (base, 1310′ A. T.),		6

The base of the quarry rock was carefully determined by checking the Barometer twice at Jackson Station. As this spot is nearly 14½ miles due west from the eastern line of Venango, where the same stratum lies 1425′ A. T. the difference of level is 115′; westward dip, 8′ per mile.

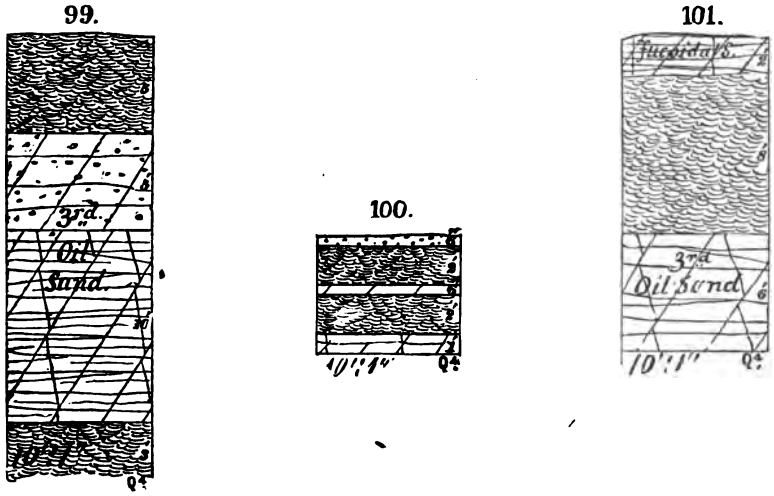
The fucoidal sandstone is a very siliceous stratum, and filled with vertically-stemmed *fucoids*, which make its surface very rough and irregular. This rock seems to be persistent, since it occurs in several townships.

The bottom rock has been quarried extensively for local use, and some has also been shipped to Erie on the Philadelphia and Erie R. R.; it is the same bluish-gray rock that we so often see at this horizon, being *saturated with petroleum*, which seeps from it slowly around the outcrop.

Reynold's boring.—The plentiful oil show induced a company to drill on the land of Mr. Reynold to a depth of

400′; but as it commenced *in* the *Third oil sand*, a productive well was not to be expected, and nothing but *gas* was obtained.

Hamit's quarry.—About 2½ miles due west from Reynold's the *Third oil sand* is again quarried on the land of Mr. Hamit; base 1285′ A. T., or 25′ lower than at Reynold's. Nothing can be seen at this exposure except the quarry portion, 5′ thick, containing much *pyrite* in one layer, as well as multitudes of *fucoids*, and the *odor of petroleum*. The



water running from the rock has a very *sulphurous* taste and odor.

Red rock.—A band of red rock comes near the center of the stratum, and a considerable portion of the stone at this quarry has to be rejected as worthless.

Veight's quarry.—About one half mile south from Hamit's the same stone was once quarried on the land of Mr. Veight and used in building locks on the old Beaver and Erie canal many years ago; this is near the McKean line.

Pierson's quarry is also in the *Third oil sand*, ¼ mile north from Veight's.

Liddell's quarry.—Just south from school house No. 5, Mr. Liddell has a stone-quarry in a rock which comes 60′ below the *Third oil sand* at 1270′ A. T. It is a fine-grained

blue sandstone, with layers 2″ to 9″ thick. It is hauled to Erie principally, and sells at the quarry for $4 per cord.

A *spirifer band* comes immediately above the sandstone.

Coal.—Mr. Liddell states that in stripping off the clay and débris above the rock, he often finds *lumps of coal*; he once collected a bushel of it and burned the same. I did not see any coal in the clay, but some chips of black slate were observed, and these may have been mistaken for coal. These slate chips belong to the *Drift* and were doubtless brought here by the ice from the Hamilton black slate outcrops of New York.

France's boring.—Just where Elk creek passes out of the township an oil well was bored on the land of Mr. C. France to a depth of 300′; a "slight show" of oil was obtained; some strong *gas veins* were struck.

Barometric elevations in Summit.

Cross roads at southern line of township near W. Blair's,	(above tide),	1470′
Forks near J. Murphy's,	"	1400′
" H. Ebenhouse's,	"	1370′
" L. Webster's,	"	1375′
" School House No. 5,	"	1280′
" R. Tenbroke's,	"	1350′
Cross roads near L. A. Hull's,	"	1290′
Forks near J. M. Hull's,	"	1270′
" L. Vaughn's,	"	1290′
Forks next east of L. Vaughn's,	"	1230′
" near J. Veight's,	"	1325′
Five Points, at Wm. Smith's,	"	1280′

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52. *Mill Creek, in Erie County.*

This large township borders Lake Erie for 11 miles east and west of the city of Erie.

The drainage of this township all passes northward into Lake Erie; Walnut and Mill creeks being the principal streams.

There is a broad level area running east and west through the township just south from its central line, with a general elevation of 950′ to 1000′ A. T. Mill creek cuts across this

and flows directly north into the Lake; but Walnut flows west along the southern slope of the highland, draining the southwestern portion off through Fairview before it enters the Lake.

The northern slope of this level area is drained by a great many small streams which plunge down with a very rapid fall to the Lake.

In many places the level stretch of land is covered with what appears to have once been beach sand, so that it probably marks the former sojourn of the Lake when it stood 400′ or more higher than now.

The rock-section exposed in Mill Creek belongs to the *Chemung flags*, *Girard shales*, and *Portage flags*.

The *Portage flags* form a broad band bordering the Lake shore, and extending up the beds of the streams much further.

The *Girard shale* forms a still wider band just south from the *Portage* outcrops.

The *Chemung flags* come in south of that, and extend to the southern line of the township—none of the hills rising high enough to take in the rocks of the *Oil Sand Group*.

Along Walnut creek the *Girard shale* is seen outcropping in long lines of ash-colored cliffs; and the top of it goes below water-level at 900′ A. T., near Smith's mill.

Along Mill creek, which flows into the Lake through Erie city, the *Girard shale* is seen finely exposed, and the top of it goes under the same near Daniel Winfield's, at 940′ A. T.

Two miles below this, near Hope Mills, we come to the *base* of the *Girard shale* at 750′ A. T., thus making its thickness, by allowing 40′ for dip in the two miles northward rise of the rocks (940′—750′)+40′=230′, which is very close to its thickness (225′) on Elk creek above Girard.

From Hope Mills to Lake Erie Mill creek flows over the alternating layers of flaggy sandstone and shales of the *Portage system* for 750′—573′=187′, and 33′ added for the nearly two miles of northward rise of the strata, gives 220′ for the thickness of the *Portage rocks* above Lake level at

Erie, and as this is about 22 miles from where the *Portage flags* first emerge above the Lake, near the mouth of Raccoon creek, it makes a dip of 10′ per mile along the Lake shore from Erie to the Ohio line.

Erie city is built mostly on a sloping terrace, which has a general elevation of 100′ to 125′ above the level of the Lake, the Union Dépot being 686′ A. T.

Gas.—During the period of oil excitement sometime in the decade beginning with 1860, a hole was bored for oil at Erie, but instead of finding much oil, plenty of gas was obtained. Soon after this it was learned that it could be obtained in almost any boring, when carried deep enough, and then its use for domestic purposes became frequent, one well often supplying all the fuel necessary for several families.

The manufacturing establishments also put down wells at their works, and the use of gas greatly lessened and in some cases entirely supplanted coal as a fuel.

Of the many wells that have been drilled in Erie I could get records of only three or four, since in most cases none were kept, and in the few that were recorded the drillers who put down the wells have moved to other parts of the country and taken the records with them. Then the rock material passed through seems to have been of the same character throughout, so that there was little inducement to keep a register of the strata passed through, since the depth at which the principal gas strike occurred in any well could be easily remembered by the owner.

Mr. J. Cawthro has drilled several wells in Erie, and one of these, a few rods northwest from the Union Dépot, gave the following record: (Fig. 102.)

"The rock material was apparently the same throughout, consisting of gray shales alternating with thin hard shells."

Cawthro well record.

1.	Conductor,	12′ to 12′
2.	Gray slate,	230′ to 242′
3.	1st gas at bottom of last.	
4.	Gray slate (2nd gas at bottom),	29′ to 271′
5.	" (3rd "),	33′ to 304′
6.	" (4th "),	65′ to 368′
7.	" (5th gas 397′, oil 392′),	29′ to 397′

8.	"	(6th gas at bottom), . .	6′ to 403′
9.	"	(7th "), . .	17′ to 420′
10.	"	(8th "), . .	24′ to 444′
11.	"	(9th "), . .	2′ to 446′
12.	"	(10th "), . .	3′ to 449′
13.	"	(gas and oil), . . .	19′ to 468′
14.	"	(gas and oil at bottom),	125′ to 593′
15.	"	(more oil at bottom), . .	53′ to 646′
16.	"	to bottom of hole, . . .	49′ to 695′

"First oil at 392′."

The well commences at 670′ above tide or about 100′ above Lake Erie and therefore 100′ down in the *Portage flags*. The first oil struck, then, at 392′, comes at an horizon 392′ +100′+225′ (Girard shale)+325′ (Chemung flags)=1042′ below the *3rd oil sand of Venango*, and may represent the *Bradford oil*, but probably not.

Mr. Cawthro has a well in another part of the city which produces 15 barrels of oil annually, besides considerable gas. The well is 840′ in depth commencing at about the same elevation as the one already given. The oil however comes mostly from about 400′ down.

Another well near this latter has yielded 1500 barrels of oil since 1864, or about 100 barrels as the annual average.

The Stearne Manufacturing Co. have two wells on their property which furnish fuel for the engines. One of these is the deepest well ever drilled in Erie of which I can get any account. Mr. Michael Flannigan who worked at the deep well while it was being drilled gave me the following items concerning it:

Stearne Manufacturing Co. deep well record.

1.	"Conductor,"	8′ to	8′
2.	"Gray flags,"	450′ to	458′
3.	"Reddish-brown shale,"	? to	——
4.	Soapstone and shales to bottom, .	? to	1418′

The heaviest gas vein came in No. 3 which Mr. Flannigan thinks was about 50′ thick, but is not certain, and the gas came near its base.

He also states that No. 4 seemed to have almost the same composition throughout, being a mass of gray "soapstone" shales with occasional thin "shells," or sandy layers 1′ to 2′ thick. No black slates of any importance were penetrated, except thin streaks which alternated with the "gray" material, hence the *Portage formation* was not passed through in this boring. The well commences at 655′ above tide or about 120′ below the top of the *Portage system*, and this would give us as the thickness of these rocks at Erie, 1418′ +120′=1538′ plus an undetermined amount not penetrated by the drill hole.

The other well at Stearne's is 500′ deep and the heavy gas vein was struck at the bottom. It commences on the same level as the deep well.

Oliver & Bacon's gas wells.—At the Canal mills, two wells have been drilled, commencing at 640′ above tide. In one of these a splendid strike of gas was made at 470′, and it supplied all the fuel used to generate steam for the first year, or an equivalent of three tons of coal daily.

In the other well a strike was made at 600′ but not so strong as in the first one. Both wells furnish about $\frac{1}{3}$ of the fuel now, and the proprietors say that the supply does not seem to be decreasing any since the great decrease which took place in each during the first two years. The wells have to be pumped out every day as the water was imperfectly cased off.

Hope Dale Mills well.—Near the south line of Erie borough, on Mill creek, a well was drilled to a depth of 650′, commencing at 730′ above tide, or only 20′ below the *top* of the *Portage formation*, which is seen just above the mill. The gas vein was struck at the bottom of the well, or 650′—(730′—573′)=493′ below Lake level, which, when we come to the Lake, 1¼ miles northward, making due allowance for the rise of the strata, would represent a horizon about 460′ below the level of the same, and this is near the horizon in which most of the gas strikes at Erie are obtained, viz:—

400′ to 500′ below Lake level, though some gas is obtained at almost every horizon.

Bell's well.—The latest large gas strike is at *The Point* on the property of H. L. Scott, 4 miles west from Erie. The hole was put down by Mr. W. E. Bell, and the great strike was made at 540′. The well commences 10′ above the level of the Lake; this gas, therefore, comes at the same geological horizon as that at Erie.

The bluffs along the Lake where the well was drilled are 80′ high, and composed entirely of Drift material. Back from the bluffs is a wide level area, which was once the floor of the Lake when it stood at a higher level than now.

Neely's quarry.—East from Erie two miles, Neely's run puts in, and one fourth mile south from its mouth a bed of sandstone is largely quarried on the land of Mr. Neely, where it comes 25′ above the Lake level. The bed is a bluish-gray sandstone 3′ thick, in three layers, the bottom one being 1½′ thick, and the others 1′ and ½′, respectively. The whole stratum has a strong *odor of petroleum*, and the quarrymen state that they frequently find heavy oil under the lowest course of stone. The rock is hauled to Erie and used wherever rough unhewn rock is needed.

Crowley's quarry, 1¼ miles east from this we come to 4 Mile run, and there near its mouth a quarry is worked on the land of Mrs. Crowley, and descending from it the following is seen (Fig. 104):

Crowley Section.

1. Sandstone (quarry), ... 2′ 6″
2. Shales, ... 20′
3. Sandy shell, ... 0′ 6″
4. Shales, with thin "shells" to Lake, ... 10′

No. 1 is a bluish-gray rock, smelling strongly of *petroleum*, and is hauled to Erie and used principally in building cellar walls.

In No. 2 were seen many specimens of "Cone-in-cone." South from the road, and further up the stream, there is another quarry at a height of 65′ above the Lake, on the land of Mr. T. Crowley, where we see 3′ of bluish-gray sandstone full of *oil and gas*.

The quarrymen say that they often strike gas veins here, since about 6′ to 8′ of blue shale has to be stripped from the quarry rock. The shales in these Portage rocks are often seen forced up in ridges with an angle of about 30°, and fractured at the crest of the miniature fold. As they occur principally along streams' beds, it would seem most probable that they had been produced by the sudden escape of imprisoned gas when the stream, in cutting down, had removed enough of the overlying rock to render the strength of its tensile power less than the elastic force of the confined gas, when it would escape explosively and fracture the shales in the way we now see them.

Continuing on up this stream the shales and thin sandstones of the *Portage* continue up to 855′ above tide where they end with a sandstone somewhat calcareous in character, and then the *Girard shale* begins:

Barometric elevations in Mill Creek.

Forks near I. Waidle's, (at south line of township,)	(above tide),	1080′
" Mrs. Moore's,	"	920′
Level of Walnut creek, opposite,	"	850′
Cross roads near J. L. Reed's,	"	930′
Forks north from S. S. McCreary's,	"	910′
Cross roads next east,	"	925′
" near G. A. Evans,	"	935′
Forks next east,	"	925′
" near W. Stair's,	"	930′
Level of Walnut creek near H. J. Hoch's,	"	865′
Forks next south,	"	920′
Cross roads east from H. Shorner's,	"	1110′
Forks near J. M. Reed's,	"	1125′
Level of Walnut creek at O. Smith's,	"	900′
Cross roads next north,	"	935′
Forks near J. Garhouse's,	"	1000′
Cross roads near J. Zuck's,	"	900′
Forks near C. Wooster's,	"	975′
Cross roads at school house near Mrs. Smith's	"	925′
Forks near M. Whitman's,	"	930′
" at Toll House on Mill creek,	"	870′
" near J. H. Miller's (east from Erie),	"	650′
" near J. Fagan's,	"	655′

53. *Harbor creek, in Erie county.*

This township borders on Lake Erie, and its southern line is just north from the divide between French creek and Lake Erie so that all its drainage is carried into the latter basin by several small streams which rise just south of the township line. The principal draining streams are 4 Mile run, 6 Mile creek, Elliot's and Scott's run, while 12 Mile creek flows through the northeast corner. These streams descend from the highlands with a very rapid fall and plow rudely parallel to one another.

The general surface of this area, leaving out the trenches cut by the streams, is a broad plain, rising gently from the Lake Erie bluffs to an elevation of 875′ A. T. (300′ above lake level) where the foot hills commence, and there the surface rises much more rapidly; this 875′ level may have been the highest point ever reached by the Lake Erie waters when it had a much greater expanse than now.

The foot-hills' level is about 2½ miles from the Lake, and can be seen extending along for a great distance; the sloping plain toward the Lake is everywhere covered with *Lake shingle*, so that there can be no doubt that Erie once covered it up to 875′ above tide. As we pass up the hills we come to another wide level space at an elevation of 1070′ or nearly 500′ above the Lake, and it seems to be covered with *Lake shingle* also; hence it is probable that this level area was once the Lake bottom, in the remote past; but a rapid cutting down of its outlet carried its surface down to the foot-hills in a very short time, thus making a sharp descent from one to the other, while subsequent erosion has almost entirely removed the Lake shingle from the intermediate portion. Going further back from the 1070′ level, toward the south, we reach another and the last level exposure at 1175′ A. T. (600′ above Lake Erie); whether or not this represents an old beach line cannot be determined, since erosion has entirely removed the evidence of Lake shingle, if any ever existed at that elevation.

The rocks of Harbor Creek belong to the *Portage flags*, the *Girard shale*, and the *Chemung flags*.

The first forms a broad band of outcrop facing the Lake, and from 1½ to 2½ miles wide; the *Girard shale* comes in south from this and occupies all the rest of the township except the highlands along the southern portion, where the surface rises high enough to take in the most of the *Chemung flags*, but does not catch any of the *Oil sand group*, the highest point coming within about 50′ of the base of these latter measures.

At the mouth of Elliott's run the following succession is seen (Fig. 105):

Elliott's Run Section.

1. Shales containing thin sandy layers, ... 25′
2. Greenish shales streaked with black to Lake level, ... 5′

The sandy layers in No. 1 are very pyritiferous, and the exposed surfaces are encrusted with copperas.

No. 2 is a grayish-green shale, in which are seen black streaks only a fraction of an inch in thickness and soon running out entirely when traced horizontally. The Lake shore consists of outcropping rocks at this locality, and the continual dash of the waves has worn them into irregular forms.

As we pass up Elliot's run from its mouth a succession of bluish shales with thin flaggy sandstone is seen until we reach a point 2½ miles south from the Lake, on the land of Mr. T. Elliot, and there at an elevation of 825′ above tide, or 250′ above Lake Erie, the *Portage flags* pass below water level, and the *Girard shale* comes into the bed of the stream.

At the mouth of the stream this 250′ of rock would be increased by the northward rise about 50′, so that there would be about 300′ of *Portage rocks* above Lake level at the mouth of Elliott's run. In going carefully over the exposed outcrop of these 300′ of strata along the stream, not a single fossil of animal origin is to be seen—nothing but *Fucoids* is found, but their abundance compensates for the absence of all traces of any other forms of life. Casts of

rain-drops, *ripple-marks*, and the peculiar fossil cast of *flowing mud*, so common in the Portage, and figured by James Hall in Geol. 4th Dist. New York, are especially abundant.

On Six Mile creek the top of the *Girard shale* goes under water-level near the Harbor Creek Woolen Factory at an elevation of 1060′ above tide, and on going south from that, the fossiliferous series of the *Chemung flags*, is seen occupying all the high ground toward the southern portion of the township.

On Elliot's run the *Girard shale* goes under near Mr. Grove's at an elevation of 1070′ above tide.

At the south line of the township near M. W. Barton's the surface rises to 1350′ above tide, and comes within about 50′ of catching the *Third oil sand*, since the latter rock should be found there at somewhere near 1400′ above tide according to the calculated dip of the strata; and, then a short distance south from this line in Greene township, we come up to the Lower Fucoidal SS. at an elevation of 1380′ above tide.

Barometric elevations in Harbor Creek.

Cross roads in Wesleyville P. O, ...	(above tide),	720′
Forks near J. M. Sterrett's, ...	"	755′
" J. Blackwood's, ...	"	790′
Top of *Portage* on 4 Mile run, ...	"	755′
Forks near S. Chamber's, ...	"	705′
" J. O'Brien's, ...	"	625′
" W. Mahoney's, ...	"	625′
Lane near M. Coner's, ...	"	625′
Forks next east, ...	"	635′
" " near Elliot's run, ...	"	625′
" near J. Boggs', ...	"	670′
" " W. Greenwood's, ...	"	720′
" next east, ...	"	715′
" near T. Elliot's, ...	"	780′
Top of *Portage* on Elliot's run, ...	"	825′
Forks near S. Stitson's, ...	"	870′
" next south, ...	"	880′
" near C. Graves', ...	"	1065′
" next south, ...	"	1090′
Cross roads near W. Tate's, ...	"	1130′
" " O. Rollin's, ...	"	1135′
" next S. W., ...	"	1115′
Level of 6 Mile creek near woolen factory, . .	"	1060′

Cross roads near E. Owens',	(above tide),	1180′
" " Wm. Henton's,	"	1225′
Forks near J. E. Barton's,	"	1230′
Cross roads near W. Barton's,	"	1350′

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54. *Greenfield, in Erie county.*

This lies directly east from Harbor creek, and extends to the New York State line for its eastern boundary, having Venango on the south, and Northeast township at the north.

It lies on the water-shed between Lake Erie and French creek, and its surface is more elevated than that of any of the townships west from it in accordance with the general rise of the land going east from the Ohio State line. Along the "divide" the elevation is about 1500′ above tide, with some few points rising still higher.

The North Branch of French creek takes its rise on the southern slope of this water-shed, and drains all the eastern and southern portions of the township. The extreme northern border and the northwest corner drain into Lake Erie.

The rocks of this area belong to the *Oil sand group* and to the *Chemung flags* below. The surface of the township is very deeply buried with Drift so that very few rock exposures can be seen.

Jones' well.—Near Greenfield P. O., on the land of Mr. E. Jones a well was once bored for oil, commencing at 1400′ above tide; no record could be obtained, but Mr. Jones gave me a few points concerning it which he remembered.

"The drive-pipe passed through 60′ of Drift before striking bed rock. Then nothing was found except soft blue slate down to bottom at 780′, when a great gas vein was struck, which threw water over the top of the derrick, and still continues to force a column of water from the hole."

At no point within this area, does the *3rd oil sand* have any exposure though it underlies quite a large scope within the township.

Barometric elevations in Greenfield.

Forks near M. E. Church west of Greenfield,	(above tide),	1460′
" next north at school house,	"	1435′

Forks at Greenfield P. O.,	(above tide),	1425′
Cross roads near J. Wilson's,	"	1460′
" " N. Mauch's,	"	1450′
Forks near school No. 2,	"	1420′
" A. Wilkinson's,	"	1435′
" O. Dunn's,	"	1465′
" J. Hartley's,	"	1460′
Level of stream near H. Carrahan's,	"	1395′
Cross roads near J. H. Coburn's,	"	1330′
Forks near G. C. Parker's,	"	1425′
" H. C. Robert's,	"	1475′
Cross road near I. Shadduck's,	"	1470′
Forks near D. Dodge's,	"	1440′
" S. B. Cole's,	"	1375′
Level of stream next south,	"	1220′

55. *North-East, in Erie County.*

This large township borders Lake Erie at the New York State line.

The southern portion of the township occupies the northern slope of the high watershed between French creek and Lake Erie, and hence its drainage is all north into the latter basin.

The principal streams are Twelve Mile creek, which drains the southwestern portion, Sixteen Mile creek draining the southeast and central parts, while the northeast corner is drained by two or three small runs and Twenty Mile creek, which cuts a profound gorge across the extreme northeastern portion of the township.

The rocks belong to the *Chemung flags*, the *Girard shale*, and the *Portage system*, this latter formation making a still broader band of outcrop facing the Lake shore than it has in any of the townships hitherto described, since the continued northeastward rise of the strata brings more of these rocks above water-level; so that if the column had not been eroded it would at the northeastern extremity of this township stand about 1050′ above tide, thus making its outcrop about 3 miles in breadth.

The *Girard shale* comes in south from this and extends to within a short distance of the southern border, except toward the eastern line.

The *Chemung flags* extend in a narrow belt along the southern and eastern half of the boundary, but in no case does the surface rise high enough to catch any of the *Oil sand group*, though the lowest portion of that series misses the hills by only about 50′.

At the southern line of the township the following succession is seen in descending along the road northward from Wm. Sweitzer's (Fig. 106):

Switzer's Section.

1. Sandy shales and thin sandstone,	40′
2. Chocolate shale,	15′
3. Blue shales,	60′
4. Spirifer band,	1′
5. Concealed,	40′
6. Blue sandstone,	4′

These measures are all quite fossiliferous, and they belong to the *Chemung flags*.

No. 4 is very limy where the outcrop has not been too long exposed to the weather.

Lathrop's quarry.—No. 6 is quarried on the land of Mr. Lathrop for building-stone; it is a rather fine-grained rock, and very blue, being also quite fossiliferous. In it were seen *Spirifera disjuncta*, *Rhynchonella contracta*, *Leiorhynchus Newberryi*, and many *Fucoids* besides.

The top of this section has an elevation of 1440′ A. T.

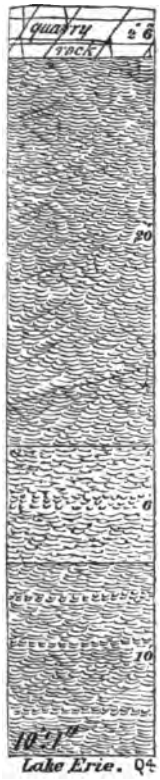
Atkin's quarry. One mile N. W. from Mr. Lathrop's we come to another quarry on the land of Mr. Atkins, at an elevation of 1300′ above tide. The rock is a bluish sandstone in layers ½′ to 1′ thick; the stratum is 5′ thick, and below it are seen 40′ of bluish-green shales containing the characteristic Chemung fossils in great abundance.

This is most probably the same stratum as the one quarried at Lathrop's.

About two miles west from Atkin's the top of the Girard shale is seen in descending from the highlands along the road toward Lake Erie, near Mrs. Leonard's, at an elevation of 1125′ above tide.

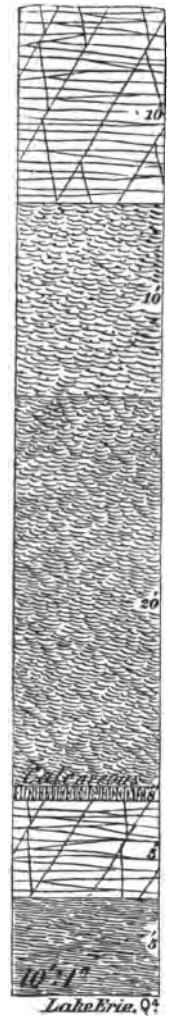
Just south from this in the bed of Twelve Mile creek the top of the *Portage flags* is seen at an elevation of 905′ above

104.



105.

107.



106.

tide, thus making the thickness of the *Girard shale* 225′, allowing 5′ for northward rise in the ¼ mile between the two exposures; this is the same thickness I found it near Girard along Elk ereek.

The foot-hills bordering the old lake plain commence at 1000′ above tide, and the wide level plain slopes gradually away toward Lake Erie, except the irregularities made by the trenches of the streams.

Where the road crosses Twelve mile creek near Mr. Houston's we see 50′ of the *Girard shale* in a perpendicular cliff along the bluff of the stream; very few sandy layers occur in it.

As we pass down Twelve Mile creek the *Portage flags* are constantly in view, being alternations of shales and flaggy sandstone, in which no organic remains except fucoids are seen.

Terrace.—Just north from the Lake Shore RR. near Mr. J. B. Caldwell's a well-defined Terrace is seen, the top of which is 795′ above tide, and we pass by a sharp descent to the next lower level at 765′. This latter wide level exposure is covered with clay near Mr. Caldwell's, which is used in brick making. From this point to the northward the slope of the old lake plain is quite small, since it has an elevation of 740′ until we come to the lake bluff, when it passes down abruptly to the lake.

At the mouth of 16 Mile creek, the following section is obtained in descending its bed to the lake from Child's mill: (Fig. 107.)

Child's Mill section.

1. Hard flaggy sandstone,	10′
2. Sandy shale,	10′
3. Dark blue fissile shale,	20′
4. Hard calcareo-silicious layer,	0′ 8″
5. Flaggy sandstone,	5′
6. Concealed to lake level,	5′

From the top of No. 1 copious springs of iron-charged waters issue, and have stained the underlying strata a deep red, as well as deposited several inches of *bog ore* in many

places. This is nearly one fourth of a mile from the lake, at the mill-dam, which is built upon No. 1.

No. 4 is a very sandy limestone and contains some iron in the form of carbonate.

In No. 5 were seen some curiously shaped *fucoids*, having the form of a horse-shoe, and being about 2½ inches across the open space. They occur here in great quantities. Many specimens of *Fucoides graphica* were also seen at this horizon.

As we ascend 16 Mile creek, a succession of shales, blue, gray, &c., alternating with thin sandstones is seen along its bed and banks until we come to A. Bucklin's two miles south from the town of Northeast, and here the *Portage flagstones* sink below the level of the stream at an elevation of 925′ above tide, and then the ashen colored shales of the *Girard* begin, and continue to form cliffs along its banks until we come to near Seeley's mill where it too goes under at 1150′ A. T., and then come the *Chemung flags* which are well exposed at the road crossing near Mr. I. McCord's. There the bluish-green shales are filled with fossils at an elevation of 1250′ A. T.

At the head of Averill run, near the New York State line, the top of the *Portage flags* is seen at an elevation of 980′ A. T., and as this is 3½ miles south from the northeastern corner of the township, the elevation of the top of the *Portage flags* would be about 1050′ at the latter locality.

Twenty Mile creek enters this township from New York, about three miles south from Lake Erie. It carries a large amount of water, and rushes down with a fall of 100′ to 150′ per mile, excavating a gorge along which the *Portage flags* are seen rising in almost perpendicular cliffs 100′ and more in height. This deep narrow cañon is termed the "Gulf," near where the creek enters this State from York, and is a famous pleasure resort in summer.

Along Twenty Mile creek, the finest exposure of the *Portage system* occurs that can be seen anywhere within the county, there being about 500′ of *Portage flags* seen from where the creek enters Lake Erie up to where the Girard shale comes into the section in the State of New York.

Near the mouth of Twenty Mile creek the stream makes a fall of 4′ over a somewhat massive stratum of dark-brownish sandstone, which smells strongly of *petroleum*.

Barometric elevations in North-East.

Village of North-East,	(above tide),	785′
North from North-East, near D. Pierce's,	"	785′
Forks of road near H. Terry's,	"	670′
" " T. Crawford's,	"	715′
Cross-roads near D. Child's,	"	610′
Forks near R. M. Crawford's,	"	725′
" " J. R. Caldwell's,	"	745′
" " B. Caldwell's,	"	765′
Cross-roads near W. Colby's,	"	795′
" " J. Clark's,	"	850′
" " J. Fuller's,	"	865′
" east from D. Houston's,	"	985′
Forks near M. C. Putman's,	"	1015′
Cross-roads near C. T. Putman's,	"	1010′
" " G. W. Law's,	"	880′
Forks near Mrs. Furgusson's,	"	1275′
Cross-road near W. Switzer's,	"	1440′
Forks near A. D. Smith's,	"	1405′
" " C. Schuldtz's,	"	1360′
" " E. S. Cole's,	"	1275′
Cross-roads near J. A. Stetson's,	"	1275′
Level of 16 Mile creek, near last,	"	1245′
Cross-roads near I. Malick's,	"	1245′
" " V. Belknap's,	"	1340′
Forks near D. Putman's,	"	940′
" " A. Martin's,	"	775′
" " J. Johnson's,	"	780′
" west from H. Janes's,	"	735′
Cross-roads near mouth 20 Mile creek,	"	645′
Forks near A. Duncan's,	"	720′
" " W. Dewey's,	"	710′
" " G. W. Butt's,	"	720′
" " A. V. Pierce's,	"	740′
Cross-roads near B. C. Town's,	"	730′
Forks next west at Vineyard,	"	735′

APPENDIX.

Notes on the Place of the Sharon Conglomerate in the Palæozoic Series. By Prof. I. C. White.

(Read before the American Philosophical Society December 17, 1880.)

With regard to the place of this rock in the series, about which there has been much diversity of opinion among geologists, I have to say that my study of it and its associated rocks during the past season in this district, as well as in Venango and Warren counties, to the east, and in the State of Ohio to the west, has dispelled the idea that I at one time entertained of the possibility of its being the Vespertine Conglomerate, or No. X of Rogers, and has confirmed me in the position that I took in my reports Q and QQ on Beaver and Lawrence counties, viz: that it is the true base of No. XII.

It may be of interest to state here the reasons which caused me to entertain such a possibility.

It happened that during my season's work in Mercer county in '78, I discovered a new limestone in the Mahoning river, only about 50′ above the horizon of the Sharon Conglomerate, and nearly 100′ below any limestone hitherto known in Western Pennsylvania. It was filled with fossils and some of them seemed to be related to Subcarboniferous types.

By a singular fatality, it also happened that the supplemental report of Prof. Orton on the Hanging Rock district of Southern Ohio came into my hands about the same time.

It is well known that in the Report in question Prof. Orton takes the ground (in which he was also sustained by the Chief Geologist, Prof. Newberry,) that the *Jackson shaft coal* of that State is of *Subcarboniferous age*, since,

as he maintained, its place comes below the horizon of the Maxville (Chester) Limestone of Andrews, and as the *Maxville* was placed in the section about 100′ above the *Jackson shaft coal*, I supposed there could be no doubt about it.

I also knew that wherever the Jackson shaft seam was placed, the *Sharon* must go with it, since the general stratigraphy, the flora connected with each, and everything else found in connection with them go to prove that they are identical.

Then the fact that Prof. Orton placed the *Maxville Limestone* the same distance below the *Zoar Limestone* (=our Lower Mercer) that I had found the *new limestone* below our *Lower Mercer*, strengthened the supposition that it might be synchronous at least with the Maxville.

And in order to bring out these new facts, I prepared a special chapter for my Report on Mercer county, QQQ, entitled "The Place of the Sharon Coal in the Rock Series," in which the facts were given that seemed to favor the view that the *Sharon Coal* was of *Subcarboniferous age*, and the Conglomerate below it, *Vespertine.*

Before the volume was published, however, I had studied the matter still further in the Crawford and Erie district, as well as elsewhere, and as before stated, saw reasons for the giving up the probability of its Subcarboniferous age. I accordingly requested Prof. Lesley to suppress the chapter in question, as its publication at that time would have done more harm than good. Hence QQQ was allowed to leave the press with Chap. VII stricken out. In the meantime Prof. Orton has written me that he will have to give up the position that he took in Vol. III, of the Ohio survey, with regard to the *Subcarboniferous age* of the *Jackson shaft coal*, and with that abandoned there remains so little evidence that the *Sharon coal* is *Subcarboniferous*, that for the present it is not worth serious consideration.

The foregoing explanation is relevant in this connection because of the currency given in Prof. Lesley's preface to QQ to the views expressed in the afterwards discarded Chapter VII, of QQQ.

But while it thus appears that the *Sharon Conglomerate*

is the true base of the Carboniferous epoch proper, it must also be remembered that like the *Sharon coal* resting on its top, it seems to have been a deposit peculiar to the *northern rim* of the Coal measures, everywhere skirting them around the north, but seldom passing far south under them, so that although toward the north the succession is definite enough, and it is plainly seen that the *Subcarboniferous rocks* end with the base of this stratum, yet toward the south in the absence of this rock the Subcarboniferous beds, with their fossils, extend up to the base of the *Sharon coal*, and in the absence of that deposit, also extend to the very base of the *Lower Connoquenessing Sandstone* which then becomes the base of the *Conglomerate series.*

Thus it is that in passing south along the Shenango and Mahoning rivers into Lawrence county, the *Cuyahoga shale*, and its fossils, are found coming up to the base of the Lower Connoquenessing Sandstone.

It follows from this northward distribution of the Sharon Conglomerate, that the marine conditions that had so widely prevailed during the closing period of the Subcarboniferous epoch, so far as Western Pennsylvania is concerned, came to an end sooner around the northern margin of the present coal field than elsewhere, that to the south, marine conditions continued to prevail, while on the northern beaches, brought above or near sea-level either by greater rising or less rapid subsidence, the Sharon Conglomerate commenced to accumulate, and continued to do so during the long time that marine conditions still obtained to the southward; finally however the incursion of the coarse sediments of the *Connoquenessing Sandstone* destroyed the life in the shallow seas southward, and so far as we know this put an end to Subcarboniferous life and conditions in Western Pennsylvania, that had already been forced a considerable distance southward by the incursion of the disturbing currents which carried the coarse material of the Sharon Conglomerate. It may even have happened that still farther south along the Chestnut Ridge region where subsidence was greater, that the marine conditions of the Subcarboniferous epoch continued to exist until the great

incursion of coarse sediment which formed the *Homewood Sandstone* and completed the *Conglomerate series*, and this indeed seems in some regions to have actually been the state of affairs since in Fayette and Westmorelond counties, Pa., and in the adjoining county of Monongahela, W. Va., the only member of the series present in any force is the Upper, or *Homewood*, and it is 175′–200′ thick. There is nothing at all to represent the *Sharon Conglomerate* of the north, and the interval between the *Umbral Limestone* and the *Homewood Sandstone* is made up of reddish and greenish shales interstratified with green sandstones which look more like *Subcarboniferous rocks* than any representatives of No. XII that I have ever seen. And in fact at times this Homewood Sandstone itself appears absent or in little force, and then the red shales of the Umbral continue up to the very base of the *Lower Productive Coal measures.*

Hence, if I am correct in this interpretation of facts, it will not do to draw a hard and fast line at any place in the series and say that everything *above* it is *Carboniferous* and everything below *Subcarboniferous;* for as well as we can unravel the history in Western Pennsylvania, it would seem that the Sharon Conglomerate at least, was in process of formation and synchronous with marine conditions prevailing further south, essentially similar to what had existed at the north previous to the change in conditions which rendered the accumulation of that mass of coarse sediment possible, and that subsequently the changed conditions at the north were carried further and further south with each great incursion of coarse material until finally the period culminated and ended by the spread of the Homewood Sandstone as an almost universal covering over Western Pennsylvania.

After this final castastrophe scarcely any of the life forms that had existed before the accumulation of the Sharon Conglomerate remained, though the process of extinction and change had been progressive toward the south from the beginning.

On this theory only, so far as I can see, can we explain the results at which Mr. W. G. Platt of the Survey Corps

seems to have arrived from the study of the rocks to the southeast in Jefferson, Indiana and Armstrong counties, viz: that the rocks of No. XI (Subcarboniferous) extend up to the base of the *Homewood sandstone*, and that *it* is the only member that can be proporly placed in No. XII. [This conclusion, however, has been set aside as erroneous by the identification of the *Sub-Homewood* strata in Mr. Platt's district with the middle and lower members of No. XII. The whole subject is discussed in the Preface to Report H⁵.—J. P. L.]

In such localities where Subcarboniferous conditions seem to have existed until the epoch of the Homewood sandstone, or top member of the Conglomerate series, it would certainly be unwise to include any lower beds in this series, and yet it seems to me equally wrong to draw the line along the base of the *Homewood sandstone* in such a case and extending it over wide areas, call everything below it Subcarboniferous.

It is a question of time against conditions. If it be right to call all rocks *Subcarboniferous* that were formed everywhere and under any surroundings until Subcarboniferous conditions had closed everywhere then it would undoubtedly be correct to draw the line squarely at the base of the Homewood sandstone; but under the broader view that discards cataclysmal changes in the Earth's history, and recognizes the now well proven fact that almost all great changes have been gradual and progressive, and that to be so they must have had a beginning somewhere in the midst of widely differing conditions, recognizing this principle it seems to me there should be no hesitation about extending the line downward from the base of the Homewood sandstone, as we proceed north, under the feather edges of these northern Conglomerates, until we reach the base of the Sharon Conglomerate, even if this latter stratum were coëtaneous with the deep sea that prevailed along the south line of Western Pennsylvania during the Chester limestone epoch, for all these conglomeratic sandstones, from the base of the Sharon to the top of the Homewood, were formed under similar conditions, and the Subcarboniferous sea at no time returned

northward to restore the life forms which the appearance of the Sharon Conglomerate had driven away forever. To do otherwise than this would be equivalent to classifying the marine deposits which are now taking place along the coasts of this country and Europe with the Cretaceous, because perchance Cretaceous life and conditions may now exist in the deep bed of the Atlantic.

I have discussed this matter somewhat at length, hoping to throw some light upon and help to harmonize the hitherto conflicting results of all who have undertaken the study of this question. It is certainly a difficult subject to deal with, but it seems to me that we have now got hold of some of the threads at least, out of which the true history of the fabric can be woven.

Philadelphia and Erie railroad.

New levels, 1879, by Mr. Welch.

Erie; frog point, E. end of old freight-house,	585′ A. T.
L. S. & M. S. RR. crossing,	685′
Belle valley,	1006′
Langdon's,	1135′
Jackson's,	1227′
Waterford,	1192′
LeBœuff,	1218′
Union,	1270′
Reilly's siding, (center),	1347′
Elgin,	1385′
Lovell's,	1374′
Buffalo, Corry & Pittsburgh RR. crossing,	1440′
Corry,	1445′
Atlantic & G. W. RR. crossing,	1427′
Columbus,	1407′
Spring creek in Warren county,	1396′
Garland,	1309′
Warren,	1195′
Clarendon,	1390′
Sheffield,	1339′
Kane,	2020′
Clarion summit,	2025′
Ridgeway,	1393′
West creek summit,	1695′
Buffalo, N. Y. & Phil. RR. junction,	1019′
Driftwood,	815′
Lock Haven,	559′
Williamsport,	528′
Sunbury,	447′
End of P. & D. RR., opposite Central Hotel,	445′

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incursion of coarse sediment which formed the *Homewood Sandstone* and completed the *Conglomerate series*, and this indeed seems in some regions to have actually been the state of affairs since in Fayette and Westmorelond counties, Pa., and in the adjoining county of Monongahela, W. Va., the only member of the series present in any force is the Upper, or *Homewood*, and it is 175′–200′ thick. There is nothing at all to represent the *Sharon Conglomerate* of the north, and the interval between the *Umbral Limestone* and the *Homewood Sandstone* is made up of reddish and greenish shales interstratified with green sandstones which look more like *Subcarboniferous rocks* than any representatives of No. XII that I have ever seen. And in fact at times this Homewood Sandstone itself appears absent or in little force, and then the red shales of the Umbral continue up to the very base of the *Lower Productive Coal measures.*

Hence, if I am correct in this interpretation of facts, it will not do to draw a hard and fast line at any place in the series and say that everything *above* it is *Carboniferous* and everything below *Subcarboniferous;* for as well as we can unravel the history in Western Pennsylvania, it would seem that the Sharon Conglomerate at least, was in process of formation and synchronous with marine conditions prevailing further south, essentially similar to what had existed at the north previous to the change in conditions which rendered the accumulation of that mass of coarse sediment possible, and that subsequently the changed conditions at the north were carried further and further south with each great incursion of coarse material until finally the period culminated and ended by the spread of the Homewood Sandstone as an almost universal covering over Western Pennsylvania.

After this final castastrophe scarcely any of the life forms that had existed before the accumulation of the Sharon Conglomerate remained, though the process of extinction and change had been progressive toward the south from the beginning.

On this theory only, so far as I can see, can we explain the results at which Mr. W. G. Platt of the Survey Corps

seems to have arrived from the study of the rocks to the southeast in Jefferson, Indiana and Armstrong counties, viz: that the rocks of No. XI (Subcarboniferous) extend up to the base of the *Homewood sandstone*, and that *it* is the only member that can be proporly placed in No. XII. [This conclusion, however, has been set aside as erroneous by the identification of the *Sub-Homewood* strata in Mr. Platt's district with the middle and lower members of No. XII. The whole subject is discussed in the Preface to Report H⁵.—J. P. L.]

In such localities where Subcarboniferous conditions seem to have existed until the epoch of the Homewood sandstone, or top member of the Conglomerate series, it would certainly be unwise to include any lower beds in this series, and yet it seems to me equally wrong to draw the line along the base of the *Homewood sandstone* in such a case and extending it over wide areas, call everything below it Subcarboniferous.

It is a question of time against conditions. If it be right to call all rocks *Subcarboniferous* that were formed everywhere and under any surroundings until Subcarboniferous conditions had closed everywhere then it would undoubtedly be correct to draw the line squarely at the base of the Homewood sandstone; but under the broader view that discards cataclysmal changes in the Earth's history, and recognizes the now well proven fact that almost all great changes have been gradual and progressive, and that to be so they must have had a beginning somewhere in the midst of widely differing conditions, recognizing this principle it seems to me there should be no hesitation about extending the line downward from the base of the Homewood sandstone, as we proceed north, under the feather edges of these northern Conglomerates, until we reach the base of the Sharon Conglomerate, even if this latter stratum were coëtaneous with the deep sea that prevailed along the south line of Western Pennsylvania during the Chester limestone epoch, for all these conglomeratic sandstones, from the base of the Sharon to the top of the Homewood, were formed under similar conditions, and the Subcarboniferous sea at no time returned

northward to restore the life forms which the appearance of the Sharon Conglomerate had driven away forever. To do otherwise than this would be equivalent to classifying the marine deposits which are now taking place along the coasts of this country and Europe with the Cretaceous, because perchance Cretaceous life and conditions may now exist in the deep bed of the Atlantic.

I have discussed this matter somewhat at length, hoping to throw some light upon and help to harmonize the hitherto conflicting results of all who have undertaken the study of this question. It is certainly a difficult subject to deal with, but it seems to me that we have now got hold of some of the threads at least, out of which the true history of the fabric can be woven.

Philadelphia and Erie railroad.

New levels, 1879, by Mr. Welch.

Erie; frog point, E. end of old freight-house,	585′ A. T.
L. S. & M. S. RR. crossing,	685′
Belle valley,	1006′
Langdon's,	1135′
Jackson's,	1227′
Waterford,	1192′
LeBœuff,	1218′
Union,	1270′
Reilly's siding, (center),	1347′
Elgin,	1385′
Lovell's,	1374′
Buffalo, Corry & Pittsburgh RR. crossing,	1440′
Corry,	1445′
Atlantic & G. W. RR. crossing,	1427′
Columbus,	1407′
Spring creek in Warren county,	1396′
Garland,	1309′
Warren,	1195′
Clarendon,	1390′
Sheffield,	1389′
Kane,	2020′
Clarion summit,	2025′
Ridgeway,	1393′
West creek summit,	1695′
Buffalo, N. Y. & Phil. RR. junction,	1019′
Driftwood,	815′
Lock Haven,	559′
Williamsport,	528′
Sunbury,	447′
End of P. & D. RR., opposite Central Hotel,	445′

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DISCOVERY

OF THE

PREGLACIAL OUTLET

OF THE

BASIN OF LAKE ERIE

INTO

LAKE ONTARIO.

BY

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Being Extracts from a Memoir in the Proceedings of the American Philosophical Society, Philadelphia, March, 18, 1881; with notes; and two maps.

DISCOVERY OF THE PREGLACIAL OUTLET

OF THE

LAKE ERIE BASIN.

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WITH TWO MAPS.

(*Read before the American Philosophical Soc., Phila, March, 1881.*)

SUMMARY.

The object of this paper is to bring before the scientific world the following observations, bearing on the Preglacial Drainage and origin of our Great Lake Basins:

1. The Niagara escarpment, after skirting the southern shores of Lake Ontario, bends at nearly right angles in the neighborhood of Hamilton, at the western end of the Lake; thence the trend is northward to Lake Huron. At the extreme western end of the lake this escarpment (at a height of about 500 feet) encloses a valley gradually narrowing to four miles, at the meridian of the western part of the city of Hamilton, where it suddenly closes to a width of a little more than two miles, to form the eastern end of the Dundas valley (proper). This valley has its two sides nearly parallel, and is bounded by vertical escarpments, which are capped with a great thickness of Niagara limestone, but having the lower beds of the slopes composed of Medina shales. On its northern side the escarpment extends for six miles to Copetown; but westward of this village it is covered with drift, but it is not absent. On its southern side the steep slopes extend for less than four miles to Ancaster, where they abruptly end in a great deposite of Drift, which there fills the valley to near its summit, but which is

partly re-excavated by the modern streams, forming gorges from two to three hundred feet deep. To the north-eastward of Ancaster these gorges are cut down through the drift to nearly the present lake level.

Westward of Ancaster, a basin ocupying a hundred square miles, where the drift is found to a great depth, forms the western extension of the Dundas valley. With the northwestern and western portions of this drift-filled area the upper portion of the Grand river and Neith's creek were formely connected. The Grand river, from Brantford to Seneca, runs near the southern boundary of this basin, then it enters its old valley, which extends from Seneca to Cayuga, with a breadth of two miles, and a depth, in modern times, of seventy-five feet, having its bed but a few feet above the surface of Lake Erie. Near Cayuga the deepest portion of the river bed is below the level of Lake Erie.

2. The Dundas valley and the country westward form a portion of a great *river valley*, filled with drift. Along and near its present southern margin this drift has been penetrated to 227 feet below the surface of Lake Ontario, thus producing a cañon with a lateral depth of 743 feet, but with a computed depth, in the middle of its course, of about 1000 feet.

3. The Grand river, at four miles south of Galt, has, since the Ice Age, left its ancient bed, which formerly connected with that of the Dundas valley, as did also Neith's creek at Paris.

4. Lake Erie emptied by a buried channel a few miles westward of the present mouth of the Grand river, and flowed for half a dozen miles to near Cayuga, where it entered the present valley, and continued its channel (reversed) to a place at a short distance westward of Seneca, whence it turned into the basin referred to above, receiving the upper waters of the Grand river and Neith's creek as tributaries, and then emptied into Lake Ontario by the Dundas valley. This channel was also deep enough to drain Lake Huron.

5. Throughout nearly the whole length of Lake Ontario, and at no great distance from its southern shore, there is

a submerged escarpment (of the Hudson River Formation) which in magnitude is comparable with the Niagara escarpment itself, now skirting the lake shore. It was along the foot of this escarpment that the river from the Dundas valley flowed (giving it the present form) to eastward of or near to Oswego, receiving many streams along its course.

5. The western portion of Lake Erie basin, the southwestern counties of Ontario, and the southern portion of the basin of Lake Huron formed one Preglacial plane, which is now covered with drift or water (or with both) to a depth varying from fifty to one hundred feet, excepting in channels where the filling by drift is very great. A deep channel draining Lake Huron extended through this region, leaving the present lake near the Au Sable river, and entering the Erie basin between Port Stanley and Vienna, at a depth near its known margin of 200 feet, but at a probable depth in the centre sufficiently great to drain Lake Huron.

6. The Preglacial valleys (now buried) of Ohio and Pennsylvania—for example; the Cuyahoga, Mahoning (reversed,) and Allegheny (deflected,) formed tributaries to the great river flowing through the Erie basin and Dundas valley.

7. The bays and inlets north of Lake Huron are true fiords in character, and are of aqueous origin.

8. The Great Lakes owe their existence to sub-aërial and fluviatile agencies, being old valleys of erosion of great age, but with their outlets closed by drift. Glaciers did not excavate the lakes and had no important action in bringing about the present topography of the basins.

9. The old outlet of the Niagara river, by the valley of St. David's, was probably an interglacial channel.

1. Introduction.

Whilst residing in Hamilton, Ontario (1877–80,) a portion of my time was devoted to studying the geology of the neighborhood. At first it began in connection with Lieut. Col. Grant, H. P., Sixteenth Regiment, and some other gentlemen, in making collections of fossils; as this locality is one of the best for obtaining Niagara fossils (and also those of the Hudson River Formation from the drift pebbles

in the beaches) in Canada. In 1874, the present writer published in the *Canadian Naturalist* a sketch of the local geology. In 1878, he laid the plan of collecting the information necessay for preparing an exhaustive paper on the Geology of the region about the western end of Lake Ontario. When systematic work was commenced, the information gained required so much time for its study that it has long delayed the publication. A large number of new species of Niagara fossils (twenty-nine of the Graptolite family alone) were obtained. The present state of the work is, that a paper on the Palæozoic Geology, and another on the Palæontology, containing descriptions of many new fossil species, are ready for publication. A third portion, on the Surface Geology, is under way; and the investigations on this subject have, step by step, carried the writer outside of his original field, having assumed an importance never anticipated, and have resulted in this advance notice of a few of the most striking facts concerning the origin of our great lakes. The completion of the work will be fnrther delayed until opportunity will have been afforded to study some questionable points, especially such as relate to the Drift deposits of the region, and others having a broader bearing on the physical geography of the lake region in Preglacial times.

In the present paper, all discussion relating to the vexed glacial hypothesis is scrupulously avoided, except those questions bearing on a true explanation of the origin of our great lakes.

In the study of the surface geology, the first great question that presented itself was "what is the origin of my native valley, Dundas?" The possibility of Lake Erie flowing down through the Dundas valley (though it suggested itself) did not seem probable, owing to the high lands between the two great lakes. However, in the *Canadian Naturalist*, 1874, I referred to it as having been produced by a "mighty river." This was like one of those gratuitous hypotheses that are common, now-a-days, for attributing to a continental ice sheet most of the causes of the present physical features of the continent, which do not readily ex-

plain themselves. Subsequently, M. George J. Hinde refers to it as having been scooped out by a glacier. This assertion will be found in the sequal to be a perfectly untenable hypothesis. Certainly, the origin of the valley was obscure, yet it showed that the excavation of a cañon of such magnitude required a proportionately great agent; and no present stream would account for even a small portion of the excavation. However, in this paper it will be seen that its existence was unquestionably occasioned by the action of a mighty river, as originally suggested. This outlet of Lake Erie also perfectly accords with, and accounts for the preglacial drainage of Pennsylvania, as made known by the report of Mr. Carll, of the Geological Survey of that State, (I.I.I, 1880.)

2. *Topography west of Lake Ontario.*

The Niagara Encarpment.—This range of hills commences its course in Central New York, and extends westward, at no great distance south of Lake Ontario. It enters Canada at Queenston Heights, and thence its trend is to the western end of the lake, where, near Hamilton, it turns northward and extends to Cabot's head and Manitoulin island. Everywhere in Canada, south of Lake Ontario, it has an abrupt fall looking towards the north, but at Thorold and other places to the eastward its brow is more broken than at Grimsby and westward. At Hamilton, the brow of the escarpment varies from 338 to 396 feet above Lake Ontario.* About five miles east of Hamilton, the escarpment makes an abrupt bend enclosing a triangular valley, down which Rosseaux creek, and other streams now flow. This valley is about two miles wide at its mouth, and has a length of about the same distance.

*Prof. Danda places the mean level of Lake Ontario at 233.5 feet above ocean-level; the Canadian Geological Survey, at 232 feet; the New York Central Railroad, at 249.84; the Geological Survey of Pennsylvania, takes 573 feet as the mean of the results of determining the level of Lake Erie; the Welland canal levels show Lake Erie as being 326.75 feet higher than Lake Ontario; and the Hamilton and North Western Railway a difference of 328 feet, both of these last routes being short lines with direct courses. Therefore the height of Lake Ontario should be about 245 feet above the sea.

About five miles westward of Hamilton, the Niagara escarpment becomes covered with the drift deposits of a broken country, or rather ends abruptly in the drift of the region. Above the range, the country gradually rises to the divide between Lake Ontario and the Grand river, or Lake Erie, without any conspicuous features. South-eastward from Hamilton, at a point about five miles from the brow of the escarpment, where the Hamilton and North Western Railway reaches the summit, the altitude above Lake Ontario is 493 feet. At Carpenter's quarry, two miles south of the "mountain" brow, at the head of James street, the altitude reaches 485 feet; and near Ancaster the summit is 510 feet above Lake Ontario. From eastward of Grimsby (for twenty miles) to near Ancaster, the escarpment presents an abrupt face for a height of from 150 to 250 feet below the summit (having a moderate amount of *talus* at the base), thence by a more or less steep series of slopes to the plane, which gradually inclines (sometimes by a succession of terraces) to the lake margin.

On the northern side of the town of Dundas, the abrupt face of the escarpment looks southward, and extends four or five miles westward, until the exposure becomes covered by the drift deposits near Copetown station, similar to the termination at Ancaster on the south side of the Dundas valley, but not by an abrupt ending as at the latter locality. About two miles east of the G. W. Railway station, at Dundas, the trend of the range bends more to the northward, and from this point there is a marked difference in the configuration of the country below the summit. The range after extending beyond Waterdown turns still more to the northward and passes near Milton, and Limehouse station (on the G. T. Railway), and thence extends to Georgian bay. The height of Copetown above the lake is 502 feet. On the west side of Glen Spencer it is 409 feet, and eastward of the same gorge the highest point is 520 feet (Niagara limestone coming within four feet of the surface). At Waterdown the altitude is over 500 feet (?) and at Limehouse the brow of the range (though only the lower beds of the Niagara limestones occur) is 810 feet. The

features of the surface of the country above the highlands north of Dundas are much more varied than south of the Dundas valley. As the trend of the escarpment turns northward around the end of the lake, the face of the slope looks toward the eastward. But the country does not present the steep declivities exhibited along the southern side of Lake Ontario; for the vertical face is usually less than 100 feet, and the country between it and the water has a more uniform pitch.

3. The Basin of Lake Ontario.

As is well known, Lake Ontario consists of a broad, shallow (considering its size) basin, excavated on the southern margin out of the Medina shales, and having its southern shores from one to several miles from the foot of the Niagara escarpment. The Medina shales form the western margin (where not covered with drift) to a point near Oakville. From this town to a point some distance eastward of Toronto, the hard rocks are made up of Hudson River age; while the soft Utica shales occupies the middle portion, and the Trenton limestones the portion of the Province towards the eastern end of the lake.

The country at the western end of the lake consists of slopes gently rising to the foot of the Niagara escarpment, noticed before. Sometimes this elevation is by terraces, and again by gentle inclines as between the foot of the scarp at Limehouse (on the G. T. Railway) and the lake, where the difference of altitude above the water is more than 700 feet, without any very conspicuous features.

At the western end of the lake, the two shores converge at an acute angle. At about five miles from the apex of this angle is the low Burlington beach, thrown across the waters in a slightly curved line, which forms the western end of the open lake. Burlington lake, thus formed, is connected with the open lake by a canal of the same name, made where there was a former shallow opening between the waters within and without the beach. This beach is made up of sand and pebbles (mostly of Hudson River age),

and is more than four miles long, but nowhere is it half a mile wide.

No mean depth of Lake Ontario can be fairly stated. For geological purposes it has no mean depth, because it is simply a long channel with the adjacent low lands covered by back-water.

West of the meridian of the Niagara river the lake is filled with more silt than eastward. This is evident from the fact that we see bottom sloping more gradually towards the centre, where the mean depth (increasing from the westward) of the channel may be fairly placed at 400 feet below the present surface of the waters. In this section of the lake, the average slope from both shores may be stated at 30 feet in a mile. At a short distance east of the 78th meridian, the character of the late bottom changes in a conspicuous manner. Here we find a deeper channel which extends for more than ninety miles, having an average depth of about 90 fathoms or 540 feet, with, in some places, a trough of about 600 feet depth, generally near the southern margin of the 90-fathom channel. Here and there is a deeper sounding—the deepest being 123 fathoms or 738 feet. The long channel, surrounded by the 90-fathom contour line, is situated at a mean distance of not less than twenty miles from the Canadian shore, whilst its southern side, approaches in some places to within six miles of the American shore, with which it is parallel. This 90-fathom channel varies from three to twelve miles in width. Its broadest and deepest portion is south of the Canadian peninsula of Prince Edwards' County.

The mean slope of the lake bottom, from the Canadian shore to this deep channel just pointed out, may be placed at less than twenty-five feet in a mile, with variations from twenty to thirty feet in that distance. The mean slope from the New York shore line to the 90-fathom channel may be placed at sixty feet in a mile, but varying generally from fifty to ninety feet. On examination we find that the greater portion of this slope belongs to a belt which descends much more rapidly than the off-shore depression.

That the southern side of Lake Ontario has a submerged

series of escarpments or one moderately steep and of great dimensions, is manifest when we come to study the soundings. In fact, if the bed of Lake Ontario were lifted out of the water, this submerged escarpment would be more conspicuous than the greater portion of the present one, known by the name of the Niagara Escarpment. In many places the descent from the table-land above the Niagara escarpment is no more precipitous than the slopes of the submerged Cambro-Silurian (Hudson River, in part, if not throughout the entire length) rocks, with its sloping summit, in part crowned by a gently sloping surface of Medina shales. Nearly north of the mouth of the Genesee river we find that within a single mile the soundings vary from forty-three to seventy-eight fathoms, (between contour lines.) This gives a sudden descent in one mile of 210 feet. As the soundings are not taken continuously to show to the contrary, most of the change of levels may be within a few hundred yards.

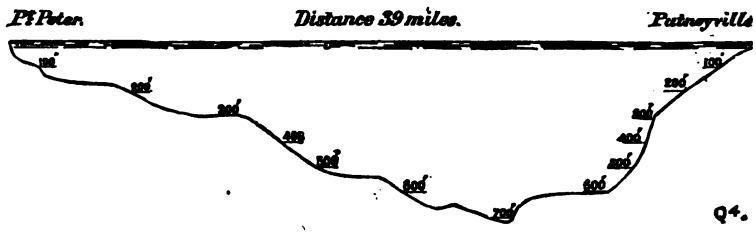
In the region of these soundings the deepest water outside of the 78 fathom line is 84 fathoms, while from the shore to the 43-fathom sounding the least distance is four and a half miles, thus giving the greatest mean slope of the lake bottom at sixty feet in a mile, before the escarpment is reached. An excellent series of soundings can be studied a line nearly northward from Pultneyville, N. Y.:

Distance from Pultneyville.	Depth of sounding.	Slope from previous sounding.
0.5 miles,	42 feet.	
1.0 "	72 "	60 feet per mile.
1.75 "	126 "	72 " "
4.125 "	246 "	50 " "
5.0 "	372 "	144 " "
6.0 " Face of the escarpment,	582 "	210 " "
7.0 "	624 "	42 " "
10.1 "	642 "	6 " "
12.0 "	738 "	48 " "

From this table it will be seen that in a distance of less than two miles, the slope of the escarpment is the difference between 582 and 246 feet, or 336 feet as actually recorded. At Hamilton, the Niagara escarpment is only 388 feet above

Fig. 1.

Section of Lake Ontario from Point Peter Light, Ontario, to Putneyville, N.Y.



the lake, which is two miles distant, whilst the present slope at Thorold is spread over nearly twice that distance. That this escarpment is not local is easily seen. For a distance of over forty miles, from near Oswego westward, it plunges down 300 feet or more in a breadth varying from less than two to three miles. Eastward and westward of this portion of the lake this submerged escarpment can be traced for nearly one hundred miles, but with the portion deeper than 70-fathom contour having more gradual soundings, as the base of the hills either originally had a more gradual slope, or the lake in its western extension has subsequently been filled with more silt.

Although we have not soundings made very close together, yet the admirable work of the United States Lake Survey is more than sufficient to prove the existance of a continuous escarpment that has an important bearing on the Preglacial geography of the region, and on the explanation of the origon of the Great Lakes themselves.

The soundings do not show a conspicuous escarpment after passing westward of the meridian of Niagara river, partly on account of the sediments filling this portion of the lake, and partly because the lake in all probability never had its channel excavated to so great a depth as further eastward.

Attention must be called to the fact that the depth of the Niagara river is 12 fathoms near its mouth, but that the lake around the outlet of the river has not a depth exceeding four fathoms, *and yet there is a rocky bottom.*

Another escarpment at the level of Lake Ontario, now

buried, was discovered by the engineers of the enlargement of the Welland canal, according to Prof. Claypole (Con. Nat. Vol. ix, No. 4). When constructing No. 1 lock at Port Dalhousie, it was found that at its northern end, there was an absence of hard rock which formed the foundation of its southern end. Rods more than 40 feet long were pushed into the slimy earth without meeting any hard rock bottom. This discovery will be noticed in the sequel. (See Report of Chief Engineer of Canadian Canals, 1880.)

4. Basin of Lake Erie.

The exceedingly shallow basin of Lake Erie has for its bottom, a plane as nearly level as any terrestrial tract could be. Its mean depth, or even maxima and minima depths from its western end for more than 150 miles, scarcely varies between 12 and 13 fathoms for the greater portion of its width. The eastern 20 miles has also a bed no deeper than the western portion. Between these two portions of the lake, the hydrography shows an area with twice this depth (the deepest sounding being 35 fathoms.) The deepest portion skirts Long Point (the extremity of a modern peninsula of lacustrine origin,) and has a somewhat transverse course. An area of less than 40 miles long has a depth of more than 20 fathoms. The deeper channel seems to turn around Long Point, and take a course towards Haldemand county, in our Canadian Province, somewhere west of Maitland. The outlet of the lake, in the direction of the Niagara river, has a rocky bottom (Corniferous limestone.)

The study of this lake at first appears less practicable than that of Ontario; but when its former outlet and its tributary rivers are described, the writer trusts that he will have made some observations which may help to clear the darkness that hangs about the history of our interesting lake region before the advent of the Ice Age.

5. The Dundas Valley.

We may consider that the Dundas valley begins at the "bluff" east of the Hamilton reservoir, and extends westward, including the location of the city of Hamilton and

the Burlington bay, at least its western portion. With this definition, the width at the Burlington heights (an old lake terrace 108 feet above present level of the water) would be less than five miles. At a mile and half westward of the heights, the valley suddenly becomes narrowed (equally on both sides of its axis of direction, by the Niagara escarpment making two equal concave bends, one on each side of the valley, whence the straight upper portion extends, the whole resembling the outline of a thistle and its stem. From this place it extends six miles westward to Copetown on the northern side; and three and a half to Ancaster on its southern side. The breadth between the limestone walls of this valley varies somewhat from two to two and a half miles. The summit angles of the limestone walls on both sides are decidedly sharp.

Dundas town is situated in this valley, its center having a height of about 70 feet above Lake Ontario, but its sides rise in terraces or abrupt hills; and, ascending the valley, we find that between the escarpments are great ranges of parallel hills separated by deep gorges or glens, excavated in the Drift by modern streams. This rugged character continues until the summit of the Post Pliocene ridges have a height equal to that of the escarpment. As the gorges ascend towards the westward they become smaller, until at some distance south-west of Copetown and Ancaster the divide of the present system of drainage is reached. Some of these streams have cut through the Drift, so that they have only an altitude above the lake (which is seven miles distant) of 240 feet, while the tops of the ridges immediately in the neighborhood are not much less than 400 feet high, though they themselves have been eroded to a depth of about another one hundred feet; for the Drift has filled the upper portion of the valley to the height of 500 feet above Lake Ontario. Even to the very sources of the streams, the country resembles the rivers of our great North Western Territories (or those of the Western States), cutting their way through deep Drift at high altitudes, which is not underlaid by harder rocks, showing deep valleys rapidly increasing in size and depth as they are clean-

ing out the soft material and hurrying down to lower levels —a strong contrast to the features in most other portions of our Province.

On the south side of the Dundas valley a few unimportant streams, mostly dry in summer, have worn back the limestone escarpment over which they flow to distances varying from a few yards to a few hundred, making glens at whose head in spring time some picturesque cascades can be seen. At Mount Albion, six miles east of Hamilton, are two of these large gorges, whose waters after passing over picturesque falls 70 feet high, and through glens several hundred yards in length, empty into the triangular valley noticed before. On the north side of Dundas valley, besides small gorges with their streams comparable to those on the south side, there are several of much larger dimensions; for example, that at Watertown, six miles north of Hamilton. Still larger is Glen Spencer which has a *cañon* half a mile long, 300 feet deep and between 200 and 300 yards wide at its mouth. At the head of this is Spencer's Falls, 135 feet high; and joining it laterally there is another *cañon*, with a considerable stream flowing from Webster's Falls, which, however, is of less height than the other. The waters feeding their streams come from north of the escarpment, and belong to a system of drainage different from those streams which flow down through the Drift of the Dundas valley, and are of much greater length. At the foot of Spencer's Falls the waters strike the upper portion of the Clinton shaly beds.

The falls now is two feet deeper than twenty years ago. Yet the stream is small, and makes a pond below in the soft shales. But this difference in height does not represent the rate of wearing or recession of the precipice. That the stream is much smaller than formerly is plainly to be seen, for at present it has cut a narrow channel above the falls from ten to fifteen yards in width and from four to six feet deep, on one side the more ancient valley which is about 50 yards wide and 30 feet deep, excavated in the Niagara dolomites.

The surfaces of the escarpment in both sides of Glens

Spencer and Webster present a peculiar aspect. That on the north-eastern side has a maximum height of 520 feet above the lake. On the same side, a section made longitudinally shows several broad shallow glens nearly a hundred feet deep crossing it and entering Glen Spencer. The surface of the rocks is glaciated, but not parallel with the direction of the channels.

On the south-western side of the same *cañon*, we find that a portion of the thin beds of the Upper Niagara limestone have been removed. This absence is not general, for it soon regains its average height of about 500 feet.

Dundas Marsh.—The eastern end of the Dundas valley contains a large swamp, nearly three miles long, with a breadth of about three-fourths of a mile, known in the early settlement of the country by the name of Coote's Paradise.

This marsh was formerly connected by a small rivulet with Burlington bay, but this was subsequently closed by the G. W. Railway, when the cutting of Desjardin's canal through Burlington heights was completed. Into this marsh all the drainage of the Dundas valley is deposited, causing it to fill up at the rate of one-tenth of a foot per annum.

Burlington Heights.—Across the eastern end of Dundas swamp and some of its branches are the Burlington Heights, varying from a few hundred yards to nearly a quarter of a mile in width, and over 100 feet in height. These have been a beach at a time when the lake level was at the same elevation, for we find that a lake beach extends along the flanks of the escarpment, both eastward and northward for a considerable distance at the same level. This is mentioned here as forming a conspicuous terrace, changing the physical character of the western extremity of Burlington bay, and the outlet of the Dundas valley. Various terraces and beaches are found at lower levels, and fragments of others are noticeable also at higher altitudes or along the side of the "mountain" some of which attain a height of 500 feet above Lake Ontario.

6. Grand River Valley.

The Grand river of Ontario, rises in the County of Gray, not more than twenty-five miles from Georgian bay and flows southward. At Elora the river assumes a conspicuous feature. Here it cuts through the Guelph dolomite rocks to a depth of about 80 feet and forms a *cañon* about 100 feet in width with vertical walls. At this place it is joined by a rivulet from the west, which has formed a tributary *cañon* similar to that of the Grand river itself.

The country in this region is so flat that it appears like a level plane. Further southward the river winds over a broader bed, and at Galt the present river valley occupies a portion of a broad depression in a country indicating a former and much more extensive valley. In fact, the old river valley existed in Preglacial times, for the present stream has reëxcavated only a part of its old bed at Galt, leaving on the flanks of one of its banks (both of which are composed of Guelph dolomites) a deposit of Post Tertiary Drift, in the form of a bed of large rounded bowlders mostly of Laurentian gneisses. The country for four miles south of Galt is of similar character, forming a broad valley, in which the present river flows. At this distance from Galt the river takes a turn to the south-westward; but at the same place, the old valley appears to pass in a nearly direct line with the course of the present bed (before the modern turn is made to the westward). As this portion of the valley now entered, has not to any extent been cleaned out by modern streams, it forms a broad shallow depression in the country a few miles wide. Yet, it is often occupied with hills composed of stratified coarse gravel belonging to that belt which extends from Owen Sound to to the County of Brent, and called by the Canadian Geological Survey "Artemesia gravel."

It is through a portion of this valley that Fairchild's creek flows. Many streams derive their supplies of water from the Beverly swamps, which also feed Lindsay creek, which empties over Webster falls down Glen Spencer through Dundas valley to Lake Ontario.

The G. W. Railway, at four miles south of Galt, enters this valley and continues in it or its branches as far as Har-

risburg, although the deeper depression is near St. George (a short distance west of Harrisburg). After leaving what I consider its more ancient bed, south of Galt (unless the country between the present bed and Fairchild's creek was an island), the Grand river flows southward to Paris and Brantford through a deep, broad valley. At the latter place the valley may fairly be described as a few miles wide, while further to the eastward the river winds in an old channel which had formerly a width of over four miles (see map). In the region of Brantford the valley is bounded by a somewhat level plateau. At Paris, Neith's creek enters the Grand river from the west, and has a valley almost comparable in size with that of the latter at this town. At Paris, the Grand river cuts through the plaster-bearing Onondaga formation. Similar rocks appear at various places along the river, at places where the river has cleaned out a portion of one side of its ancient valley.

At the Great Western Railway crossing, east of Paris the bed of the river has an altitude of 495 feet above Lake Ontario, while at Brantford it is 410 feet (this elevation may not be perfectly accurate) above the same datum. From Brantford the river winds through a broad valley, with a general easterly direction, to Seneca, where the immediate bed is about quarter of a mile wide, flowing at the southern side of a valley more than two miles wide, and 75 feet below its boundaries, which are 440 feet above Lake Ontario (see profile on subsequent page). At Seneca the bed of the present river-course is 365 feet above Lake Ontario, or only 37 feet above Lake Erie.* The H. & N. W. Railway levels

*The General Manager and Chief Engineer of the Air Line of the G. W. R. R. have recently favored me with a profile of the railroad crossing over the Grand River. I have received a like favor from the Chief Engineer of the Canada Southern. From these two lines of levels (about a mile apart) it appears that hard rock shows itself in the Drift at a few feet below the bed of the river, but at a level below that of Lake Erie water surface. The stream, at these places, occupies the eastern portion of the valley, about 2 miles from the S. or S. W. boundary of the valley, marked by the contour line of 440' above Lake Ontario, noticed S. of Seneca, but which also occurs E. of Cayuga, near the general bend in the course of the river. At both of these localities at about half a mile W. of the present site of the river, a depression in the Drift occurs to a depth but little inferior to that of the present river bed. This appears to mark the place where the ancient channel leaves what is now the modern direction of the river for a nearly direct line to the Erie Basin.

give Lake Erie as 328 feet above Lake Ontario, whilst the report of the Chief Engineer of the Welland Canal states that the difference of level is 326¾ feet. As these two levels agree so nearly, and as the other figures refer to the railway levels, I have followed them here. Eastward from Seneca the river continues to have its broad valley as far as Cayuga. To near this town the waters of the Welland canal feeder reach, at a height of about 9 (?) feet above Lake Erie.

From Seneca to Cayuga the direction of the valley is nearly south, but at the latter place it abruptly turns nearly to the eastward, and in a short distance it passes to a flatter country and flows over Corniferous limestone. After a sluggish flow, it enters Lake Erie (passing through a marshy country) at Port Maitland, more than fifteen miles in a direct line from Cayuga. It must be remembered that, from Seneca to Cayuga, the valley is broad and conspicuous. At only a short distance south of the river, at Seneca, the summit of the country is occupied by a gravel ridge.*

Returning to the valley of Fairchild's creek, we find the stream principally flowing in the former bed of the Grand river, abandoned a few miles below Galt since the Ice Age. This creek crosses the Great Western Railway at a level of fifteen feet below the crossing of the Grand river, at a few miles to the westward. Again, Fairchild's creek crosses the Brantford and Harrisburg railway at an altitude of 407 feet above Lake Ontario, or a little below that of the Grand river at Brantford, although it empties into it a few miles east of the city just named.

Fairchild's creek is now of moderate size meandering through the Drift for a width of two miles. This drift is in part stratified clay. The Grand river, from Brantford eastward, is generally excavated from the drift deposits, although occasionally one side of the valley shows rocks of Onondaga formation, exposed by the removal of the drift in modern times. It is also desirable to call attention to the fact that in the region of Brantford, much of the Onondaga formation is shaly and forms the surface country rock, covering a broad belt; whilst from Seneca eastward,

the surface of the country is more generally covered with Corniferous limestone.

7. Country between the Grand River and Dundas Valleys.

The watershed between these two present drainage systems at only a short distance south-west of Copetown, and the distance in a direction from the Fairchild's creek side to the Dundas side of this divide is less than seven miles, with an average altitude of less than 480 feet (the same as that of Fairchild's creek as it crosses the Great Western Railway). The highest point that I have leveled is 492 feet above Lake Ontario. On receding westward from the divide, the country gradually descends to Fairchild's creek, which, as it crosses the Brantford and Harrisburg Railway, is 407 above the lake. It is considerably lower where it enters the Grand river. The region between the divide and Grand river is traversed from north-west to south-east by a considerable number of streams, all with relatively large valleys, cut in the Drift since the present system of drainage was inaugurated in Post Glacial times.

The country from Jerseyville (about 465 feet above lake) slopes gradually down to the Grand river, from six to eight miles distant to the southward.

On examination, it may be seen that the country is too high to permit Fairchild's creek or Grand river, as they are at present situated, to flow over the height of land into the upper portion of the Dundas valley. As referred to before, the Niagara limestone forming the summit of the escarpment at Ancaster and eastward, has a height of about 500 feet. These beds dip at only about 25 feet in a mile (direction of dip S. 20° W.) and are not generally covered by a great thickness of Drift, but in many places are exposed on or near the surface. Westward of Ancaster these limestones are nowhere to be found, but the country is only covered with Drift. At a short distance west of this village, we find streams flowing north-easterly and easterly with very deep valleys in the Drift, indicating the absence of the floor of limestone to a depth of over 250 feet below the

surface of the escarpment. But on going westward we find that the streams have not cut to as great a depth, but are still running deeply through drift. Eventually we reach the divide, after which we find that other systems of streams, running in a south-easterly direction to join the Grand river also cut deeply in the drift; but the Niagara limestone is absent from a considerable extent of country.

On the northern side of the Dundas valley the escarpment after reaching Copetown is buried by the drift. Although the line of buried cliffs recedes somewhat to the northward of the Great Western Railway, yet there are occasional exposures, as at Troy and other places in Beverly and Flamboro, where the underlying limestones come to the surface. At Harrisburg the limestones are known to be absent for a depth of more than 72 feet, as shown in a deep well in the drift.

In the town of Paris one well came upon hard rock at 10 feet below the surface, whilst another 100 feet deep was still in bowlder clay. This last well must have been sunk in a buried channel of Neith's creek, as outcrops of gypsum-bearing beds of the Onondaga formation frequently occur near the summit of the hills.

From what has just been written, it is easily seen that the Niagara limestones are absent beneath a more or less horizontal floor (500 feet above lake on both the northern and southern sides of the Dundas valley) which continues from Dundas westward to near Harrisburg, where it meets a portion of the Grand River valley. But almost immediately west of Ancaster we find streams running northward at right angles to the escarpment, and cutting through Drift to the depth of almost hundreds of feet. In fact, if we draw a line from Dundas to a point north of Harrisburg (a mile or two), and another from Ancaster southward to the Grand River, we have two limits of a region where the limestone floor has been cut away from an otherwise generally level region. The southern side of this area is the southern margin of the Grand River valley, between Seneca and Brantford, and the western boundary is composed

of Onondaga rocks east of Paris (which perhaps forms an island of rocks buried more or less in Drift).

Additional proofs may be cited.

About a mile south of Copetown a well was sunk to the depth of 100 feet before water was obtained. Two miles south-east of the same village there is small pond only 240 feet above Lake Ontario, or more than 260 feet below the neighboring escarpment. This is in Drift.

Again, at a mile north of Jerseyville, the country has a height of 465 feet, with a well in the surface soil to a depth of 40 feet. A small rivulet flows in a valley (a few hundred yards south of the last named well) which has a bed 435 feet above the lake.

At about a mile west of Jerseyville, the altitude is 468 feet with a well 52 feet deep.

Again, at about two miles west of the same village, near the county line, the altitude is 460 feet, with a well 57 feet deep, (the bottom being lower than the Fairchild's creek more than three miles to the westward).

About a mile north of the last named station is a ravine 436 feet with the adjacent hills forty feet higher, and rising in a mile or two to about 500 feet.

All these wells are in the Drift. From exposures near Ancaster, it appears that the unstratified drift has not an altitude of much more than 400 feet. And as we know that some of these superficial beds are stratified clay, and over most of the country just described not a bowlder is to be seen, neither on the surface nor in the material taken from the greater portions of the wells, it is probable that the water is only obtained on reaching the more porous bowlder clay below. It has also been noticed that two wells, at least, are 100 feet deep before reaching water, therefore we may fairly place this as about the inferior limit of stratified superficial clays.

By reference to the accompanying map, it will be seen, then, that westward of the meridian of Ancaster there is an area of over 100 square miles from which the Niagara floor is known to be removed everywhere to a depth of 100 feet, and in its eastern portion to more than 260 feet, and

still nearer Lake Ontario to a measured depth of more than 200 feet below its waters.

8. The Buried Valley of Dundas.

That the Dundas valley is that of an ancient river valley now buried to a great depth with the débris produced in the Ice Age, becomes apparent on a careful study of the region. However, until a key was discovered the mystery of its origin was found to be very obscure. My own labors at studying this region may fairly be stated as the first systematic attempts at the solution of the present configuration of the western end of Lake Ontario and the adjacent valley. Assertions have been made that it was scooped out by a glacier, but this wild hypothesis was only a statement made without any regard to facts.

From the description of the topography, given in Section 2 of this paper, it will be seen that the apparent length of the rock-bound valley is six miles, with a width of over two miles; then it widens suddenly (eastward) to four miles (with concave curves on both sides,) after which it gradually increases in width as it opens into Lake Ontario. The direction of the axis of the valley is about N. 70° E. The summit edges of the rock-walls on both sides are sharply angular and not rounded or truncated. This angularity is not due to frost action since the Ice Age, to any extent, as is shown by the character of the talus. The rocks of the summit are frequently covered with ice markings, but I am not aware of any locality where they have been observed as being parallel with the true direction of the valley, but on all sides one can observe them (sometimes at angles of less than 30 degrees) making conspicious angles with its axis. One exception may be made to this statement. On a projecting ledge of Clinton limestone, at Russel's quarry, Hamilton at a height of 254 feet above the lake, and 134 feet below the summit of the "mountain," after the removal of some talus, I observed that the surface was polished, but with scratches so faint that they could scarcely be compared with those of fine sandpaper on wood; and the

direction, if determinable, was parallel with the overhanging escarpment. There are many tributary cañons, evidently of greater antiquity than the Ice Age, which could not have been excavated by the present streams, and are at all sorts of directions compared with the striated surface of the country.

The topography of the lower lake regions precludes the idea of a glacier flowing down the valley to the north-eastward. Again, as the direction of the ice was towards the south-west, the waters from the melting glaciers could scarcely flow up an escarpment many hundreds of feet in height. Even if the Niagara escarpment did exist elsewhere, the non-parallelism of the striæ, and and of the edges of the escarpment with their angular summits, is sufficient to prove the non-glacial origin of the valley in the hard limestone rocks. Moreover, at the eastern end of the narrower portion of the valley, there are two concave curves facing the lake, which of necessity would have been removed if such a gigantic grinding agent had been moving up the valley.

This glacier-origin of the valley being an absolutely untenable hypothesis, I sought for some fluviatile agent capable of effecting the present configuration of the region. At the time, the idea did not occur to me that the valley, large as it is at present, is only a miserable remnant of one of gigantic proportions obscured by hundreds of feet of drift. The question arose, could Lake Erie have ever emptied by this valley? This suggestion did not hold its ground for any length of time, because the present levels are all too high.

Traces of the true origin first presented themselves to me near Galt. A branch of the Great Western Railway extends from Galt southward for about four miles in the valley of the Grand river, after which, without making any important ascent, it passes into the broad older valley, described above as that in which Fairchild's creek now flows. After a careful examination of the region, and of the railway levels, I came to the conclusion that this was an old buried valley. It then became apparent that if the Grand river

had occupied the site of Fairchild's creek, the latter probably flowed down the Dundas valley, and that the Grand river, being one of the largest of the rivers of Ontario, might have been a sufficient cause for the great excavation at the western end of Lake Ontario. Having procured all the levels that bore on the subject which were available, it became necessary for me to connect several places by instrumental measurements, which I accomplished last July, with the aid of Prof. Wilkins.

As the whole floor of Niagara limestones is absent, as has previously been shown, the proof that the ancient Grand river flowed down the Dundas valley was completed, and of this discovery there was published a local notice last August.

Significant and interesting as this fact was, relative to the change of systems in our Canadian drainage, a still more important issue was involved. When taking the levels between the Dundas valley (modern) and the Grand river it was found that the whole calcareous floor was removed from a basin several miles in width, and that all the wells were sunk to a considerable depth in the Drift before water could be obtained.

On glancing at the map it will be seen that the Grand river from Brentford to Seneca meanders through a broad course which in its ancient basin is several miles in width, but that from Seneca the valley is narrower and the course of the of the stream more direct as far as Cayuga. At Seneca the valley is two miles wide, and seventy-five feet deep. Also the bed of the Grand river at Seneca is in Drift which is only 37 feet above the lake into which it now empties. As has been pointed out in the section on the topography, this broad valley continues to Cayuga within a few miles of the lake, whence its former probable course was by a nearly direct line to Lake Erie, now filled with drift, near the present bend in the river towards the eastward. At Cayuga the rock beneath the drift-bed of the river is below the lake level in the margin of its ancient valley, (see note section 2.)

Having observed the connection between the Dundas valley, Grand river and Lake Erie, it dawned on me that I had established the knowledge of a channel having a very important bearing on the surface geology of the lake region. It now became apparent that Lake Erie had flowed by the Grand river *reversed* to a point west or north-west of Seneca, and thence by the Dundas valley into Lake Ontario; also that the upper waters of the Grand river, previously discovered as passing down the Dundas valley, were really tributary to the outlet of Lake Erie, and joined it somewhere south of Harrisburg; and that the basin between Brantford (and the Grand river of to-day) and the Great Western Railway at Copetown formed an expanded lakelet along the course of the ancient outlet of Lake Erie, scooped out of the softer rocks of the Onondaga formation before noticed. As the waters excavated a bed in a deeper channel, of course this lakelet would become an expanded and depressed valley, such as we often see amongst the hills of Drift at a short distance westward of Dundas. Possibly the Grand river divided and flowed around an island, the western side of which is occupied now by the town of Paris. At any rate, Neith's creek, at that town, also formed a large tributary to the river then flowing down to Lake Ontario.

Along the course from Cayuga to Lake Ontario all obstacles to the outlet of Lake Erie appear to be removed. But along the present course of the Grand river, eastward of Cayuga, the waters flow over Corniferous limestone. But this difficulty appears to be removed on observing that the river, filled with Drift, approaches Lake Erie to within a direct distance of about five miles, but that at this place it leaves its southward course and also its conspicuous valley and flows eastward, in the same manner as the Niagara river, above the Whirlpool, left its old choked-up outlet by the valley of St. David, and cleaned out a new channel for itself through several miles, in hard rock, from Queenston southward.

Much of the Dundas valley is underlaid by stratified Erie clay, which is known to extend to a depth of 60 feet

below the surface of Lake Ontario, according to Dr. Robert Bell. In the upper part of the valley, streams have exposed some deposits of unstratified clay filled with angular shingle, derived from the thin beds of limestone forming the upper portion of the Niagara formation. In the eastern portion of the valley, the Erie clay is overlaid unconformably by brown Saugeen clay or loam (stratified). In the upper portions of the valley the hills are capped by brown clays or sands. But along some of the hillsides excavated so deeply in the Drift, we find old beaches resting unconformably on bowlder clay.

Near the center of the city of Hamilton, in the wider

Fig. 2.

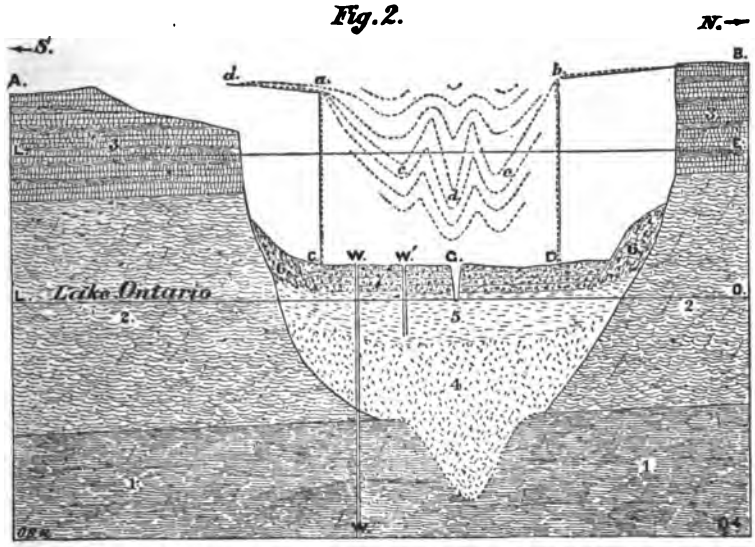


Fig. 2.—1. Hudson River formation; 2. Medina shales; 3. Niagara and Clinton Dolomites with some shales. A, C, D, B, modern valley at meridian of Burlington heights; a, C, D, b, modern valley at meridian of Dundas; a, c, d, e, b, sections across, deeply excavated in beds of streams in western part of the Dundas valley; 4. Bowlder clay filling ancient valley; 5. Erie clay; 6. Talus from sides of escarpment; 7. Old beach, 108 feet above lake at Burlington heights. G. Desjardin's canal leading from Dundas Marsh to Burlington bay; W, W, well at Royal Hotel, Hamilton; W'. another well at Dundas; L, O, level of Lake Ontario; L, E, level of Lake Erie. Horizontal scale, 2 miles to an inch; vertical scale, 400 feet to an inch.

portion of the Dundas valley, a well was sunk to the depth of 1000 feet. This well revealed a most interesting fact.

Though known to me several years ago, I did not apply it to its true bearing until recently since discovering the origin of the Dundas valley. Mr. J. M. Williams sunk this well, at the Royal Hotel, in Hamilton. He told me several years ago that he had to sink through 290 feet of bowlder, before coming to hard rock, thus causing the outlay of a large sum of money in excess of his calculations. Unfortunately, this well-record has been lost by fire. At that time, the fact was so fresh in his mind (impressed by the extraordinary cost of the well) that his statement could be relied on, he being experienced in well-borings. The mouth of this well is 63 feet above Lake Ontario, and therefore the hard rocks are absent for a depth of 227 feet below the lake surface. See section, Fig. 2.

As the valley is five miles wide at Hamilton, and as the well is only about one mile distant from its southern side, it becomes apparent that the valley in the center must have been deeper, perhaps much deeper. Moreover, if we produce the southern side of that portion of the valley, which is over two miles wide, we find that the well is less than a quarter of a mile away from it. Now if we connect the top of the Medina shales (240 feet above Lake Ontario) with the base of the Drift in the well, and produce it to the center of the valley, it would indicate a central depth of over 500 feet. At the base of the Drift there are nearly fifty feet of Medina shales, below which are the Hudson River rocks (more or less calcareous and arenaceous, mixed with the shales). This harder formation along the bed of a river would be less extensively removed by aqueous action than the overlying Medina shales, especially as the pitch of the waters would be much lessened. This graphic method of calculation seems as admissible here as it does in determining other constants of nature. However, I have placed the estimated depth in the section at about 70 fathoms below the lake surface, which depth is perfectly compatible with the soundings of the lake at no very great distance to the eastward. Even this depth gives only a very gentle slope from the sides of the river valley. It should be remarked that Burlington bay is excavated from stratified clays in

places to a depth of 78 feet. But this water is silting up comparatively quickly.

Now we have seen that the deep excavation in the Dundas valley and westward is cut through more than 250 feet of Niagara and Clinton rocks, mostly of limestone, and to such a depth in the Medina shales as to make the total known depth of the *cañon* 743 feet, but with a calculated depth in the middle of the channel, of about 1000 feet. This depth for a *cañon* is not extraordinary for Eastern America. In Tennessee there are river valleys excavated to a depth of 1600 feet, and in Pennsylvania Mr. Carll reports others equally deep.

Fig. 3.

Section of Grand River Valley at Seneca.

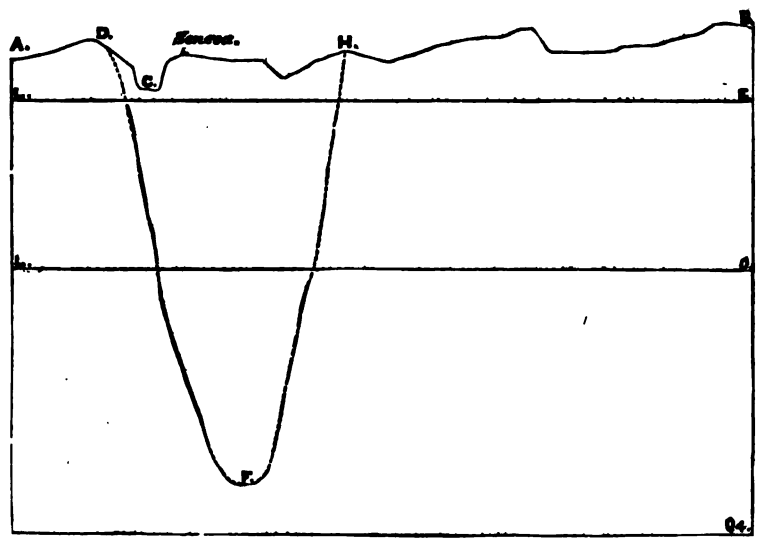


FIG. 3.—Section of Grand river valley at Seneca. A, D, C, H, B, is the profile of the H. & N. W. Railway; horizontal distance, 2 miles to an inch; vertical, 400 feet to an inch. C, represents position of Grand river; D, C, H, valley two miles wide and with maximum depth of 75 feet. L, E, level of Lake Erie; L, O, level of Lake Ontario; D, F, H, probable depth of buried valley.

Again, this Preglacial river explains the cause of the present topography of the western end of Lake Ontario. The drainage by this river swept past the foot of the sub-

merged escarpment of Lake Ontario described in preceding pages, until it passed the meridian of Oswego.

With such an outlet, and with the ancient Grand river valley buried to an equal depth, we have an easy solution to the problem of the drainage of Lake Erie. See Sec., Fig. 3.

Attention has been called in this paper to the deepest portion of Lake Erie being south of Haldimand county, and about the end of Long point, and extending transversely towards the Pennsylvania shore.

So far our remarks have applied to Canada. If we turn towards the American shore, we will see that the observations made there go very strongly in support of what has been written.

Several years since Dr. Newberry, Mr. Gilbert, and others, called attention to the deeply buried valleys of the Cuyahoga, Chagrin, Grand, Maumee and other rivers in Ohio which emptied into Lake Erie much below their present levels. The Cayahoga has its channel buried to a depth of 228 feet below the surface of Lake Erie of our time, whilst the deepest water in the neighboring portion of the lake is less than a hundred feet.

In Report III, of the Pennsylvania Geological Survey, issued in November, 1880, Mr. John F. Carll has published excellent maps of the Preglacial drainage of that State and the neighboring portions of the adjoining States. This report on the Preglacial rivers is the result of five years of investigation in the oil regions, and many of Mr. Carll's results have been derived from the facts made known by the borings for mineral oil.

Besides calling attention to the very deep valleys of erosion amongst the mountains, Mr. Carll has shown that in the oil regions the river valleys are frequently filled with drift to a depth of from 200 to 450 feet. In fact, nearly all the present rivers flow over beds deeply filled with drift. The map of the Preglacial drainage shows that the upper waters of the Allegheny emptied by the Cassadaga river (now reversed) into Lake Erie near Dunkirk, and had for tributaries many other streams which at present flow southward; for example, the Conewango. These streams drained

an area of 4000 miles, which now sends its surplus waters to the Ohio river. Again, the French and other rivers, now emptying southward from the Conneaut basin, emptied in Preglacial times into Lake Erie westward of Erie city. Again, there are some reasons for believing that the Chenango, Connoquenessing, Mahoning and other tributaries of the Beaver river (itself now emptying into the Ohio) flowed northward, by the Mahoning river reversed, to near the sources of the Grand and Cuyahoga rivers of Ohio. Hence Mr. Carll does not portray its course on his map, but from the study of the levels and character of the country, as described by the Geological Survey of Ohio, I have connected it with the Grand river of Ohio, as represented on my map. Thus there was certainly one and probably two other large water basins now flowing southward formerly emptying into the Lake Erie basin. [See note at the end of this paper.]

The deepest portion of Lake Erie is between these ancient river mouths and the ancient *débouchement* of the Erie drainage by the Grand river of Ontario, as described in these pages.

Thus we have shown a consecutive system of drainage of the former waters of the buried channels into Lake Ontario, and thence running along the foot of the submerged escarpment of the latter lake to its eastern end, receiving the Genesee and other large rivers along its course. In a portion of the present notes the writer will endeavor to make known still further the buried channels of Ontario, which exist between Lakes Huron and Erie when treating of the origin of these lakes.

The remaining portion of this paper will be devoted to the subject of the origin of our great lakes. The writer does not wish to enter here into the discussion of the drift deposits, and their origin at the present time, but to reserve it until the final report on the surface geology of the western end of Lake Ontario. Yet the facts brought to light in this study have an important bearing on the great controversy of the Glacial Drift, and lead one to the conclusion that the Ultra-Glacial theorists stand on uncertain ground.

9. Lake Superior.

As the origin of all our great lakes is so closely related, it will not be out of place to describe briefly some of the features of the upper lakes that appear most striking. In the present paper it is only intended to call attention to some of the existing physical features of these great basins of water that appear to show a relation which resulted from a more or less common origin of all our lakes. Though I have frequently visited many localities on these lakes, for this portion of the present paper I am particularly indebted to General Comstock, Superintendent of the U. S. Lake Survey, who kindly furnished me with the lake charts.

Lake Superior.—This lake may be described as a large basin with a level or gently undulating bottom and steep margins. The mean depth may be placed at 800 feet below its present surface. Very few soundings exceed 900 feet. Of these, one near the center of the basin is 954 feet, and another, not far from Duluth, is 1026 feet—the maximum depth of the lake as shown by the hydrographical survey.

The depth of the lake at three or four miles from the shore is generally as great as in its center; it is often deeper near the shore on its north-western side. However, about the Apostle islands, between the Pictured rocks and St. Mary's river, and in some of the bays, the waters are shallower than in the open lake, with their floors more or less gradually sloping as they recede from the land. As is well known, the lakes is generally surrounded by crystalline or metamorphic rocks, which rise from several hundred to even twelve or thirteen hundred feet above its surface. In short, the near shore hydrography simply shows that the present submerged margins of the lake are composed of the bases of the same rugged hills that surround it above the water. The margin of this mountain-bound basin forms a strong contrast with its floor, which, at most, is only a slightly undulating plane, extending nearly its whole length and often little less than its breadth, excepting in its south-eastern portion and some other places referred to above. In fact, the lake bottom is quite as level as most extensive planes which are now subjected to sub-aërial action.

That this great plane is not covered with any great depth of drift-deposit (excepting locally) appears evident on examining the character of the bottom of the lake in the soundings just off Kewanaw point, and those to the northward. in the various localities examined hard and rocky bottoms are alike found in both places, at the same depth and so frequently that they cannot be regarded as only rocky eminences protruding through the silt covered bottom which is generally observed.

The general direction of the deepest channel, for more than 200 miles along the north-western margin of the lake, appears to point to a river course in the region of its south-western extremity, and the few deeper holes have been produced by some receding cascade from the adjacent shore to which there appears to be a transverse deep channel south of the mouth of Gooseberry river.

Again Prof. N. H. Winchell calls attention to the depression in the low country between the Chocolate river (east of Marquette,) and Train bay (near the Pictured rocks,) as the only place where there could have been connection between the basins of Lakes Superior and Michigan. It may be remarked that some of the deeper soundings put in towards this portion of the coast, whilst to the westward and eastward the present lake bottom slopes more gradually. The soundings, however, that are near the shore, show a rocky bottom, excepting north of Laughing Fish point (Sable river,) and along a narrow channel north of the mouth of Chocolate river. The lake is very shallow for some distance westward of the St. Mary's river.

10. Lake Michigan.

This lake may be said to consist of a broad long plane, the northern half having a mean depth of about 600 feet, whilst the soundings in the southern half are not much more than half that measurement. The deepest sounding recorded is 870 feet, in the latitude of the southern end of Green bay. Throughout its whole length the lake appears to be traversed by a deep channel, and in the northern end by more than one. Although the pitch of the bottom from

the shore line is more or less gradual—generally less than 40 feet in a mile—yet, along the eastern side there is a precipitious escarpment extending for a considerable distance, which in one place suddenly descends, in a horizontal line of little over a mile, from 17 to 93 fathoms, or 456 feet, and 60 feet more in the distance of another mile.

The conspicuous channels in the submerged plane extend far northward to near the present foot of the lake. An interesting sounding east of the mouth of the Manistique river shows a depth of 448 feet, at a distance of two miles from the shore, whilst all the adjacent depths do not exceed 11 fathoms. This appears to be a continuation of the deep soundings, ten miles to the southward, but the surrounding lake bottom is covered with Drift to a great depth, wherever the Niagara limestones have been removed. It is more than probable that this great depth is in a rock-bound channel of an ancient water course, which elsewhere has been filled with Drift. It seems probable that it was a portion of a buried channel extending through the valley of the Manisique lakes to the depression in the country south of Lake Superior, alluded to above, and formed a Pregracial connection between the valleys of Lakes Superior and Michigan. Prof. Winchell regards the valley between the two lakes along the Chocolate and White Fish rivers (the latter emptying into Little Baie De Noc,) as indicating the ancient connection. This route seems less favorable, as both Little Baie de Noc and Green bay are shallow compared with Lake Michigan, for the greatest depth, which is near an outlet through Portes des Mortes, is only 32 fathoms, whilst generally the bay does not exceed 100 feet.

Green bay is separated from Lake Michigan by a Niagara escarpment facing the westward, and rising two or three hundred feet above the waters. There appears not to have been any closer connections between these two basins at any previous time than at present, excepting when the waters were at a higher level. We are told that from Green bay for 400 miles to the Mississippi river, a broad, low depression occurs in the country and many have been a former

outlet for Lake Superior. This valley is filled with Drift even if it ever had a sufficient depth.*

Grand Traverse bay has a considerable depth in both of its branches, especially in the eastern. Here we find depths to 612 feet, whilst its northern mouth is now filled, so that it does not exceed 120 feet.

The north eastern portion of the basin of Lake Michigan has a general depth of less than 100 feet, but with deeper channels running through it. Many of the soundings about the Straits of Mackinac show a rocky bottom at no great depths. The channel between the 10-fathom contour margins is not much more than a mile and a half wide, and though generally shallower, contains a hole 252 feet deep. In proceding outward, the deepest channel passes northward of Mackinac island, having a depth not exceeding 246 feet, and a width of less than a mile.

Again a depression of the country extends from near Chicago, on Lake Michigan, towards the Mississippi river, which, in some places, is known according to Dr. Newberry to be filled with Drift to a depth of more than 290 feet.

11. Lakes Huron and St. Clair.

Of these water basins we can make four divisions. The first or southern section may be made to include the shallow basin south of a line drawn from Thunder bay, or Presqu' Ile, to Kincardine, in Canada, and Lake St. Clair. The second basin comprises the deep channel of Lake Huron, and extends northward to the Manitoulin islands and the Indian peninsula; the third, the north channel between the Manitonlin islands and the Huronian hills, to the northward, the fourth, Georgian bay proper.

The first of these divisions is represented by shallow wa-

* From Gen. Warren's Report on the Transportation Route from the Mississippi river to Green Bay via the Wisconsin and Fox rivers, we learn that this valley bottom has a maximum height of 208.8′ above Green Bay; and that Lake Winnebago (169′ above Green Bay, discharges by Fox river down a series of rock rapids. Green Bay therefore never discharged into the Mississippi through the depression; consequently Lake Superior could have had no outlet to the Mississippi river via Green Bay. This makes its direct outgo into Lake Michigan at its north end the more probable.

ter, seldom 35 fathoms deep, but with a channel about 50 fathoms deep running through it, towards the north angle of the Au Sable river, near Brewster's mills. Saginaw bay, belonging to this section, is like Green bay, shallower even at its mouth, where it is less than 100 feet deep.

Lake St. Clair is a flat plane, with its bed varying from 18 to 21 feet below its surface, and is altogether modern.

At Detroit the Drift is 130 feet deep. The three south-western counties of Ontario are low and flat, and covered with Drift varying generally from 50 to 100 feet in thickness below the level of Lake Erie. In places it is known to be at least 200 feet below the Erie lake in portions of a buried channel to be noticed below. In fact, all the evidence appears to show that the southern end of Lake Huron and the western end of Lake Erie, with the intervening region, constituted one common plain, underlaid by a considerable depth of Erian shales, reposing on the thick development of Corniferous limestone, and traversed by deep channels.

The southern section of Lake Huron under consideration is mostly excavated and of Upper Erian shales in a direction at right angles to the trend of the formations. The denuding action was lessened when the waters in the deeper northern part of the lake subsided to a level having a southern margin bounded by hard Corniferous limestone, covered to no very great depth with Upper Erian shales subjected to only sub-aërial action—the whole traversed with water courses in deep channels.

The second division which, for convenience I have made of Lake Huron, is that portion between the line drawn from Presqu'Ile to Kincardine, and the Manitoulin islands to the northward. This is the deepest portion of the lake and extends in a direction running from north-west to south-east. It consists of a broad plain traversed by several deep channels. The average depth of this plain below the surface of the lake does not exceed 75 fathoms, although there are channels much deeper, one of which is represented by a depth of 117 fathoms. There is also one isolated sounding, which reaches 125 fathoms or 750 feet, this being the *deepest spot known.*

The deeper channels appear to lead from the northern portions of the lake and to unite as they proceed southward, being separated by elevations indicating peninsulas or islands. Two of the principal channels appear to proceed from Mississagua strait (between Manitoulin and Cockburn islands), and from south of Manitoulin island, eastward of the Duck islands. However, the channels in the marginal portions of the lake are generally more obscured by Drift or silt than towards the central waters. The channel, if such you can call it, proceeding from the Mackinaw straits is of inferior depth to those leading from the more northern end of the lake.

This portion of the lake is excavated out of the rocks of the various formations from the Niagara to the Corniferous limestones; but most largely out of the more or less soft rocks of the Onondaga group, and along the strike of these formations, thus giving the eroding agencies the power of removing the softer basal rocks, and of producing an escarpment of the Corniferous limestone looking to the northward, until it was finally undermined, and worn back to its present position, mostly submerged beneath the shallower waters of the southern portion of the lake, or buried in Drift deposits.

On the northern side, the lake has not made so much encroachment, as it is bounded by the hard Niagara limestones of the Manitoulin islands and Indian peninsula of Canada, the strata dipping down beneath the lake. Yet it must be noticed that these rocky shores are indented by numerous deep bays transverse to their directions.

The North Channel.—This is generally a shallow water, the greatest found depth being only 204 feet. To the north we have the Huronian rocks forming the boundary. The islands, especially towards the east and near the whole north shore, are generally composed of Trenton limestone.

The southern margin of the channel, bounded by Manitoulin and other islands, is often composed of Hudson-river more or less shaly rocks, overlaid by the Niagara limestones (where not removed by denudation), constituting an escarp-

ment facing the north. In fact the whole of the north channel is principally scooped out of the Hudson river formation, which attains a considerable thickness in this region.

Dr. Robert Bell states that he has observed fifteen anticlinal folds traversing the group of the Manitoulin islands; and it is in these that we find the great indentations and lakes of the islands, as well as the straits which separate them. Doubtless many of the southern ends of the Manitoulin lakes and channels are filled with Drift. For example, the mouth of South bay is only 33 feet deep, whilst the upper portion is generally deep, one place giving a sounding of 156 feet.

In fact, the north channel may be considered as a broad continuation of the Spanish river westward. The Mississagua river points directly to Mississagua straits, which are 204 feet deep, as deep as any part of the channel itself. Thessalon river has a direction towards False Bay De Tour, which is 186 feet deep. Vermilion river flows amongst the islands west of the Cloche mountains and probably had a connection with Lake Huron through some of the buried channels across Manitoulin islands, as between Manitouaning and South bays.

The narrow channel between the peninsula of the Cloche mountains and Manitoulin island is less than 60 feet deep and appears to be a modern connection with Georgian bay.

Georgian Bay.—The eastern and northern margins of this bay are composed of crystaline rocks; the south-eastern, of Trenton limestone; whilst the western is made up of Hudson river rocks, capped with Niagara limestone on the Indian peninsula and Manitoulin island. This basin is principally excavated out of the Utica shale and the somewhat harder rocks of the overlying Hudson River formation. It lies along the junction of the two; and thus, on the removal of the lower soft layers, an escarpment was produced which was subsequently and slowly continued to be undermined.

In the channels connecting this bay with Lake Huron,

there are many small islands separated by shallow water. Yet in one place there are two deep soundings reaching 51 and 42 fathoms. The bay itself is much deeper than these passages, for there is an escarpment submerged to a depth of 498 feet immediately off the Indian peninsula, at Cabot's Head, which is itself 324 feet above the bay. This peninsula is deeply indented with bays or fiords.

There is a depression from the southern end of the bay, through the valley occupied by Simcoe, Balsom, Rice and other lakes to the Trent river, emptying into the Bay of Quinté, an arm of Lake Ontario. This will be alluded to again.

'12. Outlet of Lake Huron.

The south-western countries of Ontario are dotted with borings for oil. From these well records, one can draw only a single conclusion, that they are underlaid by Drift (mostly stratified and perhaps wholly) to a depth of not more than 100 feet below the surface of Lake Erie, and generally to not more than 50 feet. There are deeper borings in Drift, it is true, but these may be fairly considered as in buried channels. For instance, at Detroit the Drift is 130 feet deep. Again, at Port Stanley, it is 150 feet below the surface of the lake; at Vienna it is 200 feet below Lake Erie. If we draw a line from near the northern angle of the Au Sable river (of the south) to east of Vienna, we get a boundary for the deeply Drift-filled basin of south-western Ontario; for at Tilsonburg, St. Mary's and elsewhere (just east of this line,) the hard limestones rise to near the surface of the country much above the level of Lake Erie. Excepting a few shale at Kettle Point, all the south-eastern shores of this lake are composed of sand dunes and other Post-tertiary deposits. The upper portion of the Thames and Au Sable rivers are in conspicuously Preglacial beds filled with Drift. The Au Sable after turning northward continues in a partly reëxcavated valley to a point within a mile of Lake Huron, and then turns an acute angle and runs for a dozen miles southwards parallel, and very close to the lake before emptying into it.

Now, if we look at the large geological map of Canada, it will be seen that the region underlaid by Upper Devonian shales extends south-eastward from Lake Huron, forming a narrow belt across the country to Lake Erie. Dr. Hunt has shown, that in places these shales are four or five hundred feet thick, beneath the Drift. On a careful study, it will be seen that these south-western countries of Ontario simply formed a continuation of the valley of Lake Erie to Lake Huron, or *vice versa*. The depth of this valley, or plane, as we have seen, does not exceed 100 feet below the lake level (Erie,) except in channels, and generally less than that depth; while the waters in adjacent portions of Lake Erie vary in depth from 30 feet, at the western end, to a maximum depth of 84 feet further eastward, where removed from the mass of modern sediments now being brought down by the western rivers. From these facts but one conclusion can be drawn, and that is, the deepest western portion of Lake Erie is not silted up to a greater depth than the difference between its soundings and 100 feet; except in channels, such as the Cuyahoga.

From these figures it will be seen that the country including the greater portion of Lake Erie, the southwestern counties of Ontario, and the southern portion of Lake Huron formed one nearly uniform plane, in shale rocks, which, however, gradually sloped both to the northward and eastward towards the deepest portions of the lakes. From the borings, we see that there were channels, and I think that we are furnished with the data for pointing out where the outlet of Huron formerly flowed, even to a depth sufficiently great to drain the deepest portion of the lake, although filled with some sediment. That portion of the Au Sable flowing northward to an old buried valley, and then turning southward, indicates a portion of the ancient outlet. The channel having been dammed in the Ice Age, has caused the modern river to flow in the capricious manner indicated on the map. This portion of the river reversed, formed an ancient outlet for Lake Huron, and flowed to its south-western angle, then turning eastward, the direction (with gentle curves) was south of eastward across the

country to Lake Erie, having Port Stanley on its right, and Vienna on its left bank. It is known that the channel at the former place was 150 feet, and at the latter 200 feet below Lake Erie, and with a sufficient distance between these places to have permitted of a valley four times that depth, even in the Hamilton shales, and underlying Corniferous limestones. At a distance of only a few miles eastward of this line the Corniferous limestone comes to near the surface of the country, and is exposed by several modern streams. The upper portion of the Thames, the eastern branches of the Au Sable, and other streams belong to Preglacial times with buried channels, were tributaries to this old outlet.

Throughout the southwestern counties generally there is a broad belt underlaid by several hundred feet of Devonian rocks (mostly of shale of the Hamilton group,) beneath the Drift deposits, which cover them to a depth of from 50 to 100 feet.

Two things along this route support the theory that this channel, known to be 200 feet deep (below Lake Erie,) and able to drain half of the surface of Lake Huron, was of more gigantic proportions, is the nature of the Drift near Port Stanley, and the configurations and soundings of Lake Erie. Near Port Stanley, the Drift is piled up much deeper than it is usually found in this section of the country, reaching 150 feet above the lake. From which ever cause (glacier or iceberg,) it is just what would be expected along the margin of a valley against which drift-bearing ice would be passing. The other indication is, that if we draw a line from a short distance north of Port Stanley to southward of Vienna (the direction of the valley,) it forms the continuation of a nearly direct portion of the present shore, curving slightly to Long Point, just off which the deepest portion of the lake is found, and around which the channel turns, to the Grand river of Canada. It cannot be justly said that the present configuration of the lake is independent of its Preglacial form. Nor can it be said that the lake is generally silted up to great depths, except in channels, for any such statement is unwarranted by facts, as I have shown

from the analogy between the bottom of the western end of the lake, and the south-western counties, to be improbable.

11. The Preglacial Grand River.

We are now able to construct an approximately true river map from Lake Huron to the eastern end of Lake Ontario.

The streams ran from the north and west of Lake Huron, south-eastward towards Goderich; thence southward, and entered the Au Sable near its northern angle; it turned eastward, near the southern angle of the same river, and with a gentle sweep, having Vienna on the left and Port Stanley on the right bank (receiving the upper-waters of the Au Sable and Thames as tributaries), it passed Long point, flowing near the present Canadian shore, and entering the Grand river (reversed) south of Cayuga; afterwards it passed down the Dundas valley towards north-east, into the basin of Ontario, and then along the foot of the buried Hudson river escapement to near Oswego.

Along its course, it received, probably, a small stream from near Detroit, the Maumee, Sandusky, Chagrin, Cuyahoga, Grand (of Ohio, and its tributary, the Mahoning), Conneaut, Allegheny, and other rivers from the American States, and afterwards the Genesee and various other streams in its course through the basin of Ontario.

The rate at which this basin was excavated, of course depended on the wear of the limestone rocks after entering the Grand river. But as this was very slow, the softer shaly rocks would gradually be worn down, and the basin of these lakes, in the shaly rocks, across their beds, would be greatly widened, as we see it.

No great pitch in the rivers would be required to occasion a flow of the waters, a very few inches in the mile would suffice. If we observe the deepest portions of Lake Huron and Ontario, we have a difference in altitude of 360 feet (both being below sea level) in 400 miles along the route indicated; whilst probably there were lake-expansions along the course, thus causiug the fall to be confined to a few places, especially through the Dundas Valley, in the form of a series of rapids after the capping limestones had been removed.

[The author then states his opinion of the way in which this ancient river St. Lawrence excavated the great lake basins, or open valleys, through which it passed; always undercutting in soft south dipping, nearly horizontal, rocks against the outcrops of harder and higher strata.

The train of his argument can be seen in the original memoir published by the American Philosophical Society, at Philadelphia, March 18, 1881; applied, not only to Lake Ontario but to Lakes Erie and Huron also.

I omit this portion of the memoir, because it merely makes certain theoretical statements the correctness or incorrectness of which does not at all affect the truth, value and importance of the facts described above. These are real and remarkable discoveries; and of the highest interest to the students of the geology of Erie and Crawford counties, as the reader will have already noticed. The publication of Dr. Spencer's work in upper Canada comes just in the nick of time for the Pennsylvania survey, confirming and further explaining Mr. Carll's conclusions; while it throws light upon the report of Mr. White.

With regard to Dr. Spencer's theory of the river erosion of Lake Ontario and Lake Erie, I have only to say, that it is too narrow to satisfy *all* the demands made upon it. For a number of years past I have been urging upon geologists, especially those addicted to the glacial hypotheses of erosion, the strict analogy existing between the *submerged* valleys of Lakes Michigan, Huron, and Erie, and the whole series of *dry* Appalachian "Valleys of VIII" stretching from the Hudson river to Alabama; also, of Green Bay, Lake Ontario and Lake Champlain with all the dry "Valleys of II and III." One single law of topography governs the erosion of them all, with out exception, whether at present traversed by small streams, or great rivers, or occupied by sheets of water; the only agency or method of erosion common to all being that by rain water; not in the form of a great river, because many of them neither are now nor ever have been great water ways.

As a consequence of their absolute similarity of geological position, general form and common genesis, their *age* must be

one and the same. The sea has had nothing to do with their production, for it has never permanently invaded some of them, nor even temporarily others. Ice has had nothing to do with their production for those in the glacial region differ in no respect from those nearest the gulf of Mexico.

I also long ago urged on theorists the necessity for taking into account as a prime factor *the underground solution of limestone strata*, and the subsequent aqueous removal of the fallen débris of overlying strata, the roofings of caverns and the steeps of cliffs. In regard to this I have pointed to the horizontal Niagara limestone which floors the three middle lakes, and the Trenton limestone which floors the two lower lakes and Green and Georgian bays. A curious present illustration of what has been the state of things is offered for the examination of geologists by the peninsula of Yucatan, on the surface of which are no streams of water, the drainage of the whole country being underground.

It is needless to repeat the oft-told demonstration; but it is well, now that Dr. Spencer has disembarrassed us of the chief difficulty of our last pre-recent water system of the north, to remind the admirers of his great discovery that his new found ancient Grand river did its work not only with the constant assistance, from the beginning to the end, of millions of smaller rivers, creeks, runs and rills, but also in such subordination to them as a general acknowledges to his troops, or a contractor to his army of navvies.

No *great* river can be looked upon as a principal eroding agent. *Rain water erodes in the direct ratio of the number of its threads; and in the inverse ratio of the volume of their united floods.* The rill, the cascade, the rivulet, have the highest proportional erosive power. Small rivers act vigorously so long as they descend steep slopes, but lose their power gradually as they enter plains. Large rivers are *constructive* rather than *destructive.* Lakes with outlets to the ocean are merely large rivers of great breadth, with exceedingly sluggish currents and an erosion-force reduced to a minimum. The oceans are merely exaggerated and connected lakes traversed by still larger currents, with the minimum of erosive power reduced to nearly zero.

Therefore our Great Lake basins, although traversed by a great river, were not excavated by it; but by the universal vertical descent of rain water upon their areas, lowering their surfaces gradually and nearly equally at all points, while at the same time mining it throughout the whole extent of its limestone underfloor; the material being removed, in the ordinary way, by rills, rivulets and the great river, to the sea.

Dr. Spencer's scorn of the erosive power of glaciers leads him to quote Professor Whitney's admirable and equally contemptuous arguments against it,* in addition to such as he draws himself from the condition of the escarpments and the direction of the scratches. These were substantially anticipated as long ago as 1858 in Prof. Henry D. Rogers' description of the glacial striæ of the Wilkes-Barre valley conforming to its already completely established topography.—J. P. L.]

14. The Outlet of Lake Ontario.

The question involved in the sub-aërial and fluviatile origin of our three Great Lakes, is where are the outlets of Lake Ontario, Lake Erie and Lake Huron, at sufficient depths to drain their basins. As shown, the outlet of Lake Erie through the Dundas valley is sufficiently deep to empty the two upper lakes. Also, the outlet described on previous pages points to every condition necessary to indicate its depth as being sufficiently great to empty Lake Huron, although the actual measurement (on the north-east side of the channel) has only reached to 200 feet below the surface of Lake Erie, with a bottom composed of soft shales.

There remains one other question to be answered, but certainly one of no greater moment than the ancient connection between Lakes Erie and Ontario—where was the outlet of Lake Ontario?

Dr. Newberry, at times a glacialist, finally appears to advocate the glacial excavation of the lakes after their courses had been determined by river action.

Various writers for the last twenty years have referred

* Dr. Dawson has shown that northwest America *was* a glacial region.

to the deep buried channel near Lake Onondaga, more than 400 feet below its surface, as indicating the former outlet of Lake Ontario by this route, and down the Mohawk to the Hudson river. This course will not answer, as Mr. Carll has shown, for at Little Falls, Herkimer county, the Mohawk flows over metamorphic rock.

Various fluvialists infer some buried route by the St. Lawrence. This seems scarcely possible, as that great river flows over hard rocks at various points for 200 miles below Lake Ontario, unless the outlet existed somewhere between Kingston in Canada, and Oswego in New York, and continued in a buried course to eastward of Montreal. The north-eastern portion of Lake Ontario is very shallow, and the deepest channel points to the south-eastward extremity of the lake.

At the present time the writer knows nothing positively of the most probable outlet, if that by the Mohawk will not answer. Yet he will predict that its outlet will be found as certainly as the one between Lakes Erie and Ontario, of which there was no clue, or even suggestion until working up the origin of the Dundas valley. One other route presents itself, but as positive proof is not at hand, I will defer theorizing.

[The interesting question thus propounded by Dr. Spencer may not be soon satisfactorily answered. The descent of the great water-way of the Lakes eastward calls for some outlet in that direction, and this can only be looked for along an eastward prolongation of the southern shore of Lake Ontario. The present Mohawk valley would suffice, if it were a *Buried Valley* filled to its present flood-plain with Drift. But the bed of the Mohawk is solid rock at Little Falls, at about 350′, A. T.*

There seems no hope of finding a buried valley on the south side of the Mohawk valley, for the Caughnawahgah and other streams descending from the Heldelburg wall on

*R. R. grade 376′; See. N. p. 105. Three miles east of Utica "Mohawk low water" is given at 393.33′. In 21 miles the R. R. grade falls (eastward, from Utica depot to Little Falls depot, from 410′ to 376′) 34′.

that side show the slates in their beds; nor on the north side of the valley, for the Trenton and other creeks enter the Mohawk from the north as cascades.

Further east the difficulty is more flagrant; for the valley is barred across by several uplifts of gneiss, making transverse rock ridges 500 feet high, through which the river breaks by narrow gateways; as at the Nose, four miles west of Amsterdam, where the water surface is about 240′ A. T. (having fallen about 100′ in 40 miles, from Little Rock to Amsterdam.)

If the Ontario lake river, then flowed at 130 fathoms beneath present lake level (250), i. e. (780′—250′=)530′ *below* present tide level, and yet its outlet waters flowed over the Mohawk rock bed at Little Falls, 350′ *above* present tide level, the country about Little Falls must have been elevated (query: by the Mohawk uplifts, as items of a more general general Hudson river uplift?) *more* then (530′+350′=)900′. And this may possibly give us a rude geological date for the elevation of the Catskill mountain plateau, sloping westward into Pennsylvania.—J. P. L.]

15. Niagara River.

That the Niagara river is postglacial, at least from the Whirlpool to Queenston, is apparent. It is known that the Niagara river formerly left its present course near the Whirlpool and flowed down the valley of St. David, which is now filled with drift. This valley (through the limestone escarpment) is not so great as the present *cañon*. This buried valley of St. David could only have been produced after the closing of the Dundas valley outlet of the Erie basin, for until then the waters flowed at a very much lower level.

Therefore, it seems necessary to regard this channel (not of very great magnitude) as an interglacial outlet for Lake Erie.

The geologists of the western States point to the forest bed as a period of high elevation, preceded by the Erie clay (stratified) and succeeded by the yellow stratified clays or loam, corresponding to the Brown Sangren clay of Canada, which is unconformable to the underlying Erie clays (or

bowlder clay in the upper portion of the Dundas valley). So, for the present, we look upon the old course of the Niagara river as the channel excavated during the warm interglacial period.

[It only remains to suggest to the citizens of Crawford and Erie county that their outlooks from the great divide, and their picnics at "the gulf" will now have an added charm, if they will picture to themselves a former state of things, when, instead of the broad expanse of water which they are accustomed to gaze down upon with so much pleasure and show with such pride to friends who visit them from afar, there once spread out an illimitable landscape of forest covered plains, gently rising towards the distant north. From the southeast and from the southwest descended into this plain from the New York, Pennsylvania and Ohio State highlands a range of rapid rivers, the Allegheny, the French, the Mahoning, the Cuyahoga, the Black, the Vermillion and the Sandusky cascading downwards through profound gorges—to unite in one. Joined on the far side of the plain by a mighty river coming from the northwest, the assembled floods entered and passed north through a long cañon into the magnificent amphitheater of Dundas; to leave it again by a narrow gate, with walls a thousand feet high, and to descend upon the plain of Ontario, on their way to the ocean.

Let them then imagine centuries to roll on; the great glacial winter of the world setting in; the slow accumulation of a thousand feet of snow and ice upon the Laurentian mountains; the southward advance of the front of the continental glacier; its occupation of the whole landscape with an east and west frontage of a thousand miles; damming back the rivers and converting the forest covered plain into an inland sea; closing up the cañons with gravel and sand; filling the amphitheater of Dundas; banking itself against the Pennsylvania upland and sending long separate glaciers down across the country of the Middle States as far south as the limit of heat-endurance.

Then let them imagine the slow retreat of the meteor;

the melting of every trace of the ice; the new topography produced by its abundant debris; the establishment of Lake Erie and the upper lakes; the reversal of the Pennsylvania and Ohio river systems southward; the opening of the new vents at St. David's and Kingston; the lowering of the lake waters from terrace to terrace; the rapid cutting back of Niagara Falls and the establishment of the present lake level.

Whether the Glacial Age was single or double—whether the Drift be divisible by the "forest bed" into two formations or not—whether the high terraces of Erie county be older or younger than the lower ones—whether the Great Preglacial river kept open for a time its channel ways beneath the ice-sheet or not—all these are subordinate features of a scene which is essentially a part of the veritable history of our continent, suggestive of the most inspiring thoughts, and worthy of the study of intelligent beings.

Additional note. — On the 15th of April Dr. Spencer communicated to the American Philosophical Society a suggestion of some importance, which may in the course of future investigations lead to a serious enlargement of the great Erie water basin of Preglacial times.

After passing in review the facts related by Prof. White in his Reports Q and Q² on Beaver and Lawrence counties, and specially referring to the remarkable shallowness of the ancient river channel of the Ohio at Steubenville, he suggests the following way out of the difficulties of the case:

Suppose the drainage of the Lower Alleghany, Clarion, Redbank, Mahoning, Conemaugh, Yough, Cheat, and Monongahela to pass Pittsburgh as the Ohio as far as Beaver, and to be joined there by a small river, represented now by the Little Beaver, with a southern branch heading up between Youngstown and Steubenville:

Suppose the combined waters then to *ascend* the Beaver valley (*descending* on the old now buried channel bed) to Newcastle, there to receive the streams represented by the Lower Shenango waters:

Suppose the great river thus reënforced to flow on northwestward (still in almost a straight course all the way from

Pittsburg) up the present valley of the Mahoning (now filled with from 150 to 200 feet of Drift) to the depression in the water-shed in Ohio:

It would only require a depth of 300 feet of Drift in a buried rock-bed channel through this depression to allow the continuance of the river into and down the present Grand river of Ohio into Lake Erie.

Unfortunately we have no borings in the Drift between the head of the Mahoning and the Grand river, and therefore cannot *prove* the existence of the required buried channel; nor, if one exists, its sufficient depth to satisfy the requirements.—J. P. L.]

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